draft ENVIRONMENTAL STATEMENT

Eastern Powder River Coal

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DEPARTMENT OF THE INTERIOR

DRAFT

ENVIRONMENTAL STATEMENT

PROPOSED

DEVELOPMENT OF COAL RESOURCES

IN

THE EASTERN POWDER RIVER BASIN OF WYOMING

Prepared by the

DEPARTMENT OF THE INTERIOR

State Director, Wyoming State Office
Bureau of Land Management

SUMMARY

Draft (x) Final ( ) Environmental Statement

Department of the Interior, Bureau of Land Management

1. Type of Action: Administrative (x) Legislative ( )

2. Brief Description of Action: The site specific analysis is based on one formal proposal (Buckskin Mine) for mining federal coal by 1980, 1985, 1990, and end of mine life. This environmental statement is developed in two parts: an updated regional analysis of the cumulative impacts of existing and anticipated coal development activities through 1990 and site specific mining and reclamation plan analysis.
Involved are:

A. Approval of one mining and reclamation plan on an existing lease.

B. An updated analysis of 9 operating mines and 5 mines with environment statements in progress.

C. Assessment of additional activities which contribute to the cumulative impact of coal development in the region.

Annual production estimates for the Buckskin Mine total 2 million tons by 1980, 4 million tons by 1985, 4 million tons by 1990, and 4 million tons till the end of mine life. Combined with existing mining expected to continue through 1990, a total of 173 million tons would be produced annually by that date.

3. Summary of Cumulative Environmental Impacts by 1990:

A. Population of the region would increase by 21,565 over 1978 base.

B. Employment in the region would increase by 3,900 jobs.

C. Distribution of social order due to rapid growth and subsequent changes in community structure.

D. Conflict in "new" and "old" life styles. Small town atmosphere would be lost.

E. Transportation arteries, including rail lines, would experience heavier average daily traffic loading with significant accident potential.

F. Industrial and municipal use of water would increase 26,210 acre-feet per year, possibly reducing amount available for other uses.

G. Water quality would be lowered; total dissolved solids would increase.

H. Air quality would be lowered in terms of all presently regulated pollutants.

I. Vegetation would be disturbed and destruction of soil horizons would occur on 50,603 acres.

J. Possible overall reduction of soil and vegetative productivity of mined areas even after reclamation.

K. Livestock and wildlife forage would be reduced by 109,300 animal unit months (AUMs) during mining.

L. Soil and vegetative (4,752 AUMs) productivity and wildlife habitat would be permanently lost on 2,200 acres converted to urbanization.

M. Recreation use would be intensified, urban recreation needs would not meet increased population needs, and outdoor recreation experiences would decline.

N. Wildlife habitat, carrying capacity, and populations would be adversely affected on 50,603 acres.

O. Present visual quality of the landscape would be changed or altered as a result of mining, mine facilities, new roads, railroads, and transmission lines, and urban expansion.

P. Approximately two billion tons of coal would be extracted.

Q. Cultural resources in areas of surface disturbance would be committed to either destruction or salvage and increased amateur collecting would occur.

R. Topography of mined areas, presently consisting of cliffs, abrupt breaks, and rolling hills, would change to smoother contours.

S. Some geologic contacts, strata, and fossil occurrences would be revealed and during the mining process others would be destroyed.

4. Alternatives Considered: Two alternatives are presented in Chapter 8, The No-Action Alternative (Low Level Scenario) and High Level Scenario. The low level scenario is based on existing coal mines with a coal production of over 1,853 million short tons by 1990. The high level scenario is based on proposed, existing, and potential coal mining with a coal production of 2,378 million short tons by 1990.

5. Comments on the draft environmental statement have been requested from various agencies, state clearing house, and interest groups. See Chapter 9.

6. Date Draft was made available to EPA and the Public: October 25, 1978.

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PROPOSED BUCKSKIN MINE

CHAPTER 1

DESCRIPTION OF REGIONAL DEVELOPMENT ACTIVITY

BACKGROUND

Introduction

This environmental statement (ES) is in two parts. The first part is an updated regional analysis of the cumulative impacts of existing and anticipated coal development activity through 1990 in the region known as the Eastern Powder River Basin of Wyoming. Additional development activity in the region includes coal conversion, extraction and processing of other energy minerals (uranium, oil, and gas), development of utility and transportation systems, and activity related to population growth. This additional activity would contribute to the cumulative impact of coal development in the region.

The second part of this environmental statement analyzes impacts of the site-specific action, which is approval of the Buckskin mining and reclamation plan submitted by Shell Oil Company. Development of the Buckskin Mine is included in the cumulative development activity assessed in the regional analysis.

Purpose of the Regional Update

This regional analysis has been prepared to update the regional analysis contained in the Final Environmental Impact Statement, Eastern Powder River Coal Basin of Wyoming (FES 74-55) filed on October 18, 1974. The update will provide an assessment and analysis of cumulative regional impacts based on current coal production outlook and presently anticipated levels of regional development activity. This update will also incorporate recent data, research, and impact analyses in subjects as air quality, water resources, soils and vegetation, cultural resources, transportation, and socioeconomic conditions.

The environmental statement prepared in 1974 covered the probable regional impact of the development and operation of fourteen coal strip mines, four mine-mouth, coal-fired generating plants, two gasification plants, and a 113-mile main line railroad connecting Gillette and Douglas. The statement also analyzed, on a site-specific basis, development or expansion of four mines (Wyodak, Rawhide, Black Thunder, and Jacobs Ranch) and the 113-mile railroad.

Since FES 74-55 was issued in 1974, the development or expansion of the four mines analyzed site specifically has been approved by the U.S. Geological Survey (USGS). Three mines (Belle Ayr, Cordero, and Eagle Butte) included in the earlier regional analysis and analyzed in separate site specific environmental statements have also been approved by USGS. Five additional mines (Caballo, Coal Creek, East Gillette, Pronghorn, and Rochelle) included in the earlier regional analysis are presently being analyzed in separate site-specific environmental statements. The status of coal mining approvals is summarized in Table R1-1. The right-of-way for the 113-mile railroad has recently been issued. The four new mine-mouth, coal-fired generating plants and two coal gasification plants have not been developed at this time. Completion of the Wyodak Plant discussed in FES 74-55 occurred in 1978, and no additional new power plants are currently projected within the region through the time period 1990. The Panhandle Eastern Gasification Plant on a site near Douglas is still in the proposal stage, pending funding for construction and operation.

Scope of Regional Analysis

The scope of this updated regional analysis includes the cumulative impacts of existing and anticipated coal development together with impacts resulting from other developments occurring or expected to occur within the Eastern Powder River Basin Environmental Statement (ES) region by 1990. The ES region is the same as that analyzed in FES 74-55 (see Figure R1-1). The geographic area of consideration is that part of the Powder River Basin in Wyoming bounded by the Powder River on the west, the coal outcrop on the east, the Wyoming state line on the north, and the North Platte River on the south. The ES region, consisting of approximately 5 million acres (4,978,560 acres), includes all of Campbell County and a portion of Converse County. The principal communities are Gillette, Douglas, Glenrock, and Wright, Wyoming. The boundary of the region coincides exactly with the Eastern Powder River Basin Planning Unit within the Casper District of the Bureau of Land Management.

Those impacts which extend beyond the ES region are analyzed to the extent that they are more associated with regional development than with other actions outside the region. Elements which will be impacted on a broader geographic scope include social and economic factors, recreation, air quality, and transportation systems.

This document has been prepared by the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS) in cooperation with the U.S. Forest

TABLE R1-1

STATUS OF COAL MINING OPERATIONS

Mine Name	Approved	FES* issued	DES** issued	DES in Preparation
Wyodak	X	10/74		
Dave Johnston	X	--***		
Belle Ayr	X	10/75		
Cordero	X	4/76		
Rawhide	X	10/74		
Black Thunder	X	10/74		
Jacobs Ranch	X	10/74		
Kerr McGee #16	X	--****		
Eagle Butte	X	9/76		
Caballo				X
Coal Creek				X
East Gillette			X (4/77)	
Rochelle				X
Pronghorn			X (7/78)	

* Final Environmental Statement
** Draft Environmental Statement
*** Approval prior to enactment of National Environmental Policy Act.
**** No federal approval required.

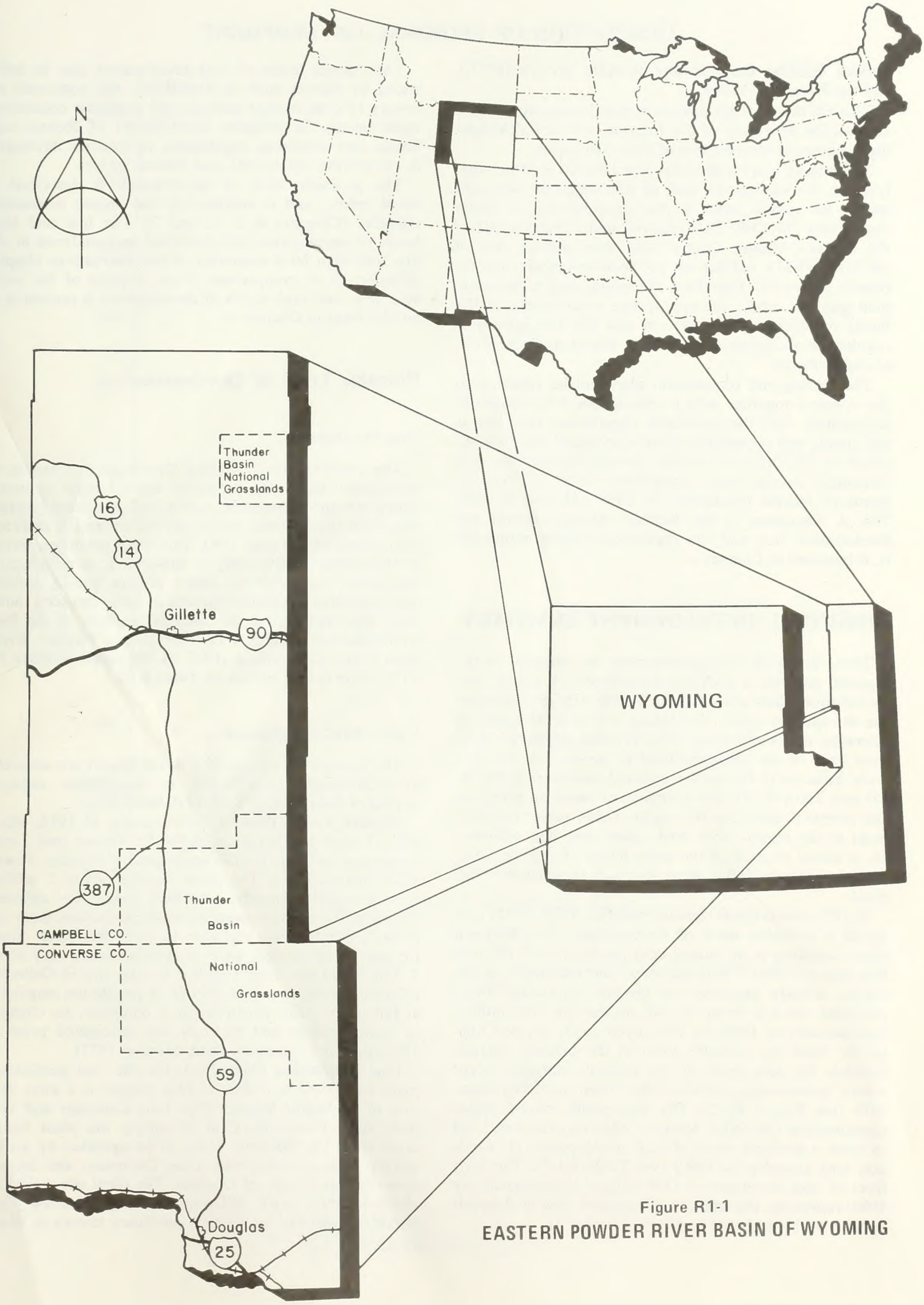


Figure R1-1
EASTERN POWDER RIVER BASIN OF WYOMING

Service (USFS), the Fish and Wildlife Service (FWS), and the Bureau of Mines.

This ES does not propose new coal leasing nor does it commit the Secretary of the Interior to a new coal-leasing program or the issuance of new coal leases.

The mining and reclamation plan (Buckskin Mine) analyzed in the site-specific part of this statement was submitted for review prior to the promulgation of initial regulations (30 CFR 700) required under Section 502 of the Surface Mining Control and Reclamation Act of 1977 (PL 95-87), and has not yet been reviewed for compliance therewith. Therefore, the mining and reclamation plan may not reflect the appropriate requirements of the initial regulations. However, in this ES the applicable regulations are being considered in this analysis as federal requirements.

The mining and reclamation plan will be returned to the operator together with a request that it be revised in accordance with the applicable regulations. As soon as the mining and reclamation plan is revised it will be evaluated by the Office of Surface Mining Reclamation Enforcement to determine compliance with the requirements of federal regulations 30 CFR 211 and 30 CFR 700. A discussion of the Surface Mining Control and Reclamation Act, and the regulations which implement it, is included in Chapter 3.

REGIONAL DEVELOPMENT SUMMARY

Three levels of coal development are assessed in the regional analysis: a probable level based on mining and reclamation plans presently filed with USGS (including the site-specific action, Buckskin); a low level based on operating mines and those mines pending approval which have been or are being analyzed in site-specific ESs and were included in the earlier regional statement (FES 74-55) (see Table R1-1); and a high level based on proposed and potential mining in the region. Other major development in the region, both coal-related and noncoal-related, is added to each of the three levels of coal development in order to define three levels of regional development.

In 1974, the original regional analysis (FES 74-55) projected a probable level of development from fourteen mines resulting in an annual coal production of 150 million tons by 1990. There are now fourteen mines in the region, already approved or pending approval, which represent the low level of coal production (169 million tons annually by 1990) for the current analysis (see Chapter 8). Thus the probable level in the original analysis parallels the low level of the current analysis, except where production outlooks have been modified since 1974 (see Figure R1-2). The site-specific action under consideration (Buckskin Mine) is added to the low level to form a probable level of coal development (173 million tons annually by 1990) (see Table R1-2). The high level of coal development (329 million tons annually by 1990) represents the addition of potential new coal development to the probable level (see Chapter 8).

The various levels of coal development may be influenced by factors such as availability and economic recovery of coal, market demand and economic conditions, requirements for diligent development of federal coal leases, and decisions, regulations, or policies developed in the private, local, state, and federal sectors.

The probable level of development is described in detail below, and is analyzed in the impact assessment chapters (Chapters 4, 5, 6, and 7). The low and high levels of development are described and analyzed in the low and high level scenarios of the alternatives chapter (Chapter 8). A comparison of the impacts of the probable, low, and high levels of development is presented in tabular form in Chapter 8.

Probable Level of Development

Coal Development

The probable level of coal development consists of production from one proposed mine, whose approval constitutes the site-specific action, and associated production from the fourteen previously or separately analyzed mines through the year 1990. The mines pending approval are assessed individually in site-specific environmental statements completed or under preparation by USGS. The cumulative regional impacts of these fourteen mines were also included in the regional analysis in the final environmental statement on the Eastern Powder River Coal Basin of Wyoming (FES 74-55) issued October 18, 1974. Mine data is shown on Table R1-2.

Coal-Related Development

The impacts of coal-related development are analyzed as components contributing to cumulative regional impact of the probable level of development.

Wyodak Power Plant. In the summer of 1978, Black Hills Power and Light and Pacific Power and Light companies opened the 330-Mw capacity Wyodak Power Plant near Gillette. The plant requires about 2 million tons of coal annually, supplied from the adjacent Wyodak Mine which must increase production from the present 900,000 tons per year to meet this need. Since the plant is air cooled, water requirements are only about 130 acre-feet per year, supplied by the city of Gillette's effluent treatment system. About 75 people are employed at the plant. After construction is complete, no changes in plant facilities and capacity are anticipated prior to 1990 (personal communication, Morgan 1977).

Coal Gasification Plant. Plans for one coal gasification plant have been announced. This project is a joint venture of Panhandle Eastern Pipe Line Company and Peabody Coal Company. Coal to supply the plant would come from the Rochelle Mine, to be operated by a subsidiary known as Rochelle Coal Company, and located about 48 miles north of Douglas. The plant site would be about 15 miles north of Douglas. The gasification plant would be operated by another subsidiary known as Wyo-

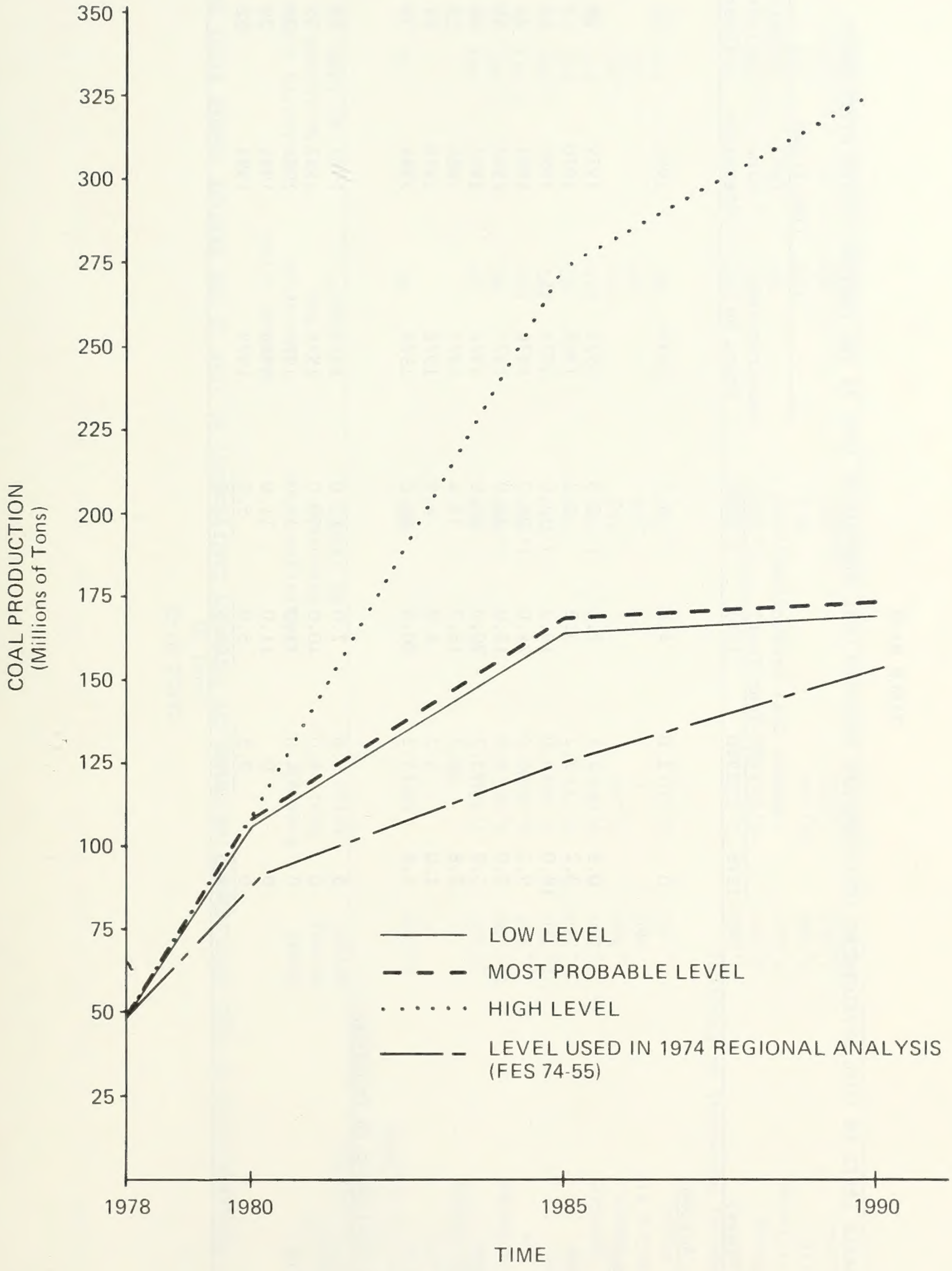


Figure R1-2
LEVELS OF COAL PRODUCTION

TABLE R1-2

PROBABLE LEVEL OF COAL DEVELOPMENT (EXISTING AND PROPOSED COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Projects (All Surface Mines)	Annual Coal Production (MM Tons/Year) 1978	1980	1985	1990	Time Frame: Construction Start Up	Full Mine Operation	Mine Life (Years)
Site Specific Action							
Buckskin	0	2.0	4.0	4.0	1979	1985	20
Operating Mines							
Wyodak	0.9	2.5	2.5	2.5	1922	1979	98
Dave Johnston	3.2	3.2	3.2	3.2	1958	1970	43
Belle Ayr	18.0	16.0	19.0	19.0	1973	1985	23
Cordero	9.2	20.0	24.0	24.0	1976	1981	25
Rawhide	3.0	9.0	12.0	12.0	1977	1982	40
Black Thunder	5.8	13.7	20.0	20.0	1978	1983	40
Jacobs Ranch	2.6	10.7	15.7	15.4	1975	1984	23
Kerr-McGee #16	1.0	4.2	4.2	4.2	1978	1979	14
Eagle Butte	5.8	13.2	20.0	20.0	1978	1984	39
Environmental Statement In Progress							
Caballo	0	3.0	7.0	12.0	1977	1987	39
Coal Creek	0	4.0	10.0	10.0	1978	1983	36
East Gillette	0	4.0	11.0	11.0	1979	1982	35
Rochelle[1]	0	0	11.0	11.0	1980	1984	29
Pronghorn	0	3.5	5.0	5.0	1979	1981	22
TOTAL	49.5	109.0	168.6	173.3			

TABLE R1-2
(cont'd)
PROBABLE LEVEL OF COAL DEVELOPMENT (EXISTING AND PROPOSED COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Projects (All Surface Mines)	Total Permit Acres[2]	Federal Coal Acres	Cumulative Acres Disturbed by 1990[3]	Average Acres Disturbed Per Year[4]	Cumulative Acres Reclaimed by 1990
Site Specific Action					
Buckskin	1,760	600	377	50	14
Operating Mines					
Wyodak	3,240	1,880	363	50	243
Dave Johnston	13,990	9,660	2,760	80	1,565
Belle Ayr	5,960	2,360	1,947	165	1,643
Cordero	8,390	6,560	3,174	285	1,820
Rawhide	5,720	5,457	755	80	410
Black Thunder	8,280	5,884	1,285	175	975
Jacobs Ranch	4,960	4,352	1,760	170	1,345
Kerr McGee #16	960	0	559	57	572
Eagle Butte	4,470	3,520	1,208	85	611
Environmental Statement In Progress					
Caballo	7,850	5,330	1,220	195	805
Coal Creek	9,605	5,800	1,270	185	808
East Gillette	3,440	3,440	1,100	77	990
Rochelle	5,000	10,820	873	160	555
Pronghorn	2,640	4,000	455	45	310
TOTAL	86,265	69,663	19,106	1,859	12,666

TABLE R1-2
(cont'd)
PROBABLE LEVEL OF COAL DEVELOPMENT (EXISTING AND PROPOSED COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Projects (All Surface Mines)	EMPLOYMENT[5] 1980 Construction	1980 Permanent	1985 Construction	1985 Permanent	1990 Construction	1990 Permanent
Site Specific Action						
Buckskin	25	125	0	133	0	133
Operating Mines						
Wyodak	0	48	0	55	0	55
Dave Johnston	0	135	0	135	0	135
Belle Ayr	0	255	0	334	0	334
Cordero	0	166	0	277	0	277
Rawhide	0	327	0	430	0	430
Black Thunder	0	350	0	500	0	500
Jacobs Ranch	0	212	0	250	0	250
Kerr McGee #16	0	123	0	123	0	125
Eagle Butte	0	211	0	350	0	350
Environmental Statement In Progress						
Caballo	121	200	0	430	0	430
Coal Creek	194	55	0	250	0	250
East Gillette	5	110	5	161	0	161
Rochelle	200	190	0	190	0	190
Pronghorn	0	226	0	279	0	279
TOTAL	545	2,733	5	3,897	0	3,899

TABLE R1-2
(cont'd)
PROBABLE LEVEL OF COAL DEVELOPMENT (EXISTING AND PROPOSED COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Projects (All Surface Mines)	Estimated Number of Unit Trains for the Years[6] 1980	1985	1990	Market Area
Site Specific Action				
Buckskin	200	400	400	Oklahoma
Operating Mines				
Wyodak	45[7]	45[7]	45[7]	Mine Mouth (Wyodak), South Dakota
Dave Johnston	0[7]	0[7]	0[7]	Mine Mouth (Dave Johnston Power Plant)
Belle Ayr	1,600	1,900	1,900	Colorado, Texas, Arkansas, Kansas, Ohio, Iowa
Cordero	2,000	2,400	2,400	Wyoming, Texas
Rawhide	900	1,200	1,200	Iowa, Indiana
Black Thunder	1,370	2,000	2,000	Texas
Jacobs Ranch	1,070	1,570	1,540	Arkansas, Louisiana
Kerr McGee #16	420	420	420	Unknown
Eagle Butte	1,320	2,000	2,000	Southern, Midwestern, and Ohio Valley States
Environmental Statement in Progress				
Caballo	300	700	1,200	Nebraska, Michigan, Indiana
Coal Creek	400	1,000	1,000	Texas
East Gillette	400	1,100	1,100	Unknown
Rochelle	0[7]	0[7]	0[7]	Mine Mouth (Wyoming Coal Gasification)
Pronghorn	350	500	500	Minnesota, Iowa, Wisconsin, Illinois, Gulf Coast States
TOTAL	10,375	15,235	15,705	

Note: Mine information was developed from mining and reclamation plans currently on file with the Area Mining Supervisor, USGS.

1 Additional federal coal reserves under lease are anticipated to be mined as a part of this operation in the future, which may extend indicated mine life.
2 All acreage within the area of operations for the mine.
3 Only acreage disturbed by mining operations. By 1990, 3,717 additional acres will be disturbed by mine facilities.
4 Average annual rate per new surface disturbance by mining activities.
5 Employment data in the mining and reclamation plans were updated where possible by personal communications with the mining companies.
6 One unit train equals 100 cars, each car having a capacity of 100 tons of coal. Does not include return traffic. Coal exported from the region is shipped south, east, or southeast.
7 This number does not represent full transport of the mine production by unit train. Coal consumed at mine mouth is generally transported short distances by truck or private rail.

ming Coal Gas Company (SERNCO 1974). This plant was included in the cumulative regional analysis presented in FES 74-55. Information concerning this proposal has been updated for this ES.

The gasification plant would require 1,000 acres for facilities, plus additional acreage for access roads, rail line, and pipelines. It would process 11 million tons of coal annually and require 5,000 to 8,000 acre-feet of water annually. From this, 270 million cubic feet per day of 960 to 970 BTU per cubic foot of gas would be produced. By-products would be 8,000 barrels of liquid petroleum products and about 100 tons of sulfur per day. The company has proposed constructing a power plant of 60-Mw capacity to supply electrical needs of the plant.

The proposed gasification plant would require a 24-inch, 475-mile gas line. About 20 miles of this line would be in the region of analysis and would require 200 acres of land. Water would be supplied from a diversion on the North Platte River and from a well field adjacent to the plant site. The water system would require about 10 miles of water pipeline. A private railroad would be established between the Rochelle Mine and the plant site. This line would be single track with sidings and electric powered. The line would be about 40 miles long and basically parallel State Highway 59 (personal communication, Leon Fergus 1977).

Presently, the gasification project plans are not proceeding, pending financial arrangements. For purposes of analysis, financing is assumed to be available by 1980. When financing becomes available, at least 2 years (1982) would elapse before construction begins. Construction would require about 4 years and employ an average of 2,000 workers. Permanent employment at the plant would be about 800 individuals.

This proposal is included in the cumulative regional analysis. However, a site-specific environmental analysis will be prepared at the time a specific gasification project is proposed.

Railroad. Most coal produced in the region will be exported to other parts of the United States to be converted or utilized.

Rail service is provided via two main lines of Burlington Northern (BN) (principal rail service) and one main line of Chicago and North Western (C&NW). Upgrading of existing tracks is presently in progress. BN and C&NW are jointly constructing a major new rail line between Gillette and Douglas, portions of which are in operation (personal communication, Interstate Commerce Commission 1977). Construction and operation of this rail line was analyzed both regionally and site specifically in FES 74-55, and federal rights-of-way were issued March 20, 1978. (See also Chapter 2, Transportation.) It is expected that about 173 miles of rail line and anticipated spur lines and sidings will be constructed by 1990 as mines begin production (from mining and reclamation plans on file with the Area Mining Supervisor, USGS). In addition, a 40-mile private rail line for transporting coal for gasification (see discussion of coal gasification) would be built by 1990 (personal communication, Leon Fergus 1977). The main line between Gillette and Douglas, about 113 miles, will probably be completed between 1980 and 1985. Spur line development would be timed to coincide with industry start-up periods. Projections in this ES indicate that coal production could increase from a present 50 million tons per year to 173 millions tons per year in 1990. Rail transport requirements would be affected similarly. The quantity of coal to be shipped would increase at a fairly constant rate to 1990 (personal communication, Interstate Commerce Commission 1977), based on coal production projections.

Other Major Regional Development

The impacts of major noncoal developments are included in the regional analysis as part of the cumulative regional impacts.

Oil and Gas. Oil and gas production was recorded from 166 active fields in the Powder River Basin during 1975. There are an additional 44 fields which are considered temporarily nonproductive. A great majority of the wells classed as nonproductive are shut in, awaiting secondary or tertiary recovery procedures to be implemented. These shut-in wells are considered to be in the process of reactivation.

The region produced approximately 12.3 million barrels of federal oil, or approximately 9% of the total federal oil produced in the state of Wyoming in 1975.

Oil and gas reserves will become increasingly depleted by present extraction methods, and total production figures have shown a decline since 1973. However, a highly active oil and gas exploration program in the region is expected to continue to add new fields to the discovery list. Also, new recovery methods, such as the secondary and tertiary programs, will tend to improve recovery by extending oil and gas operations in the region for at least 50 years.

Employment in the oil and gas industry in the region was approximately 5,000 people in 1974, and by 1990 is expected to increase to only 3% above the present figure. Total acreage presently used for oil and gas activity is about 4,800 acres. Acreage affected by oil and gas exploration and development will increase about 10% by 1990 (personal communication, USGS, Conservation Division, Casper 1977).

Uranium. Uranium exploration and mining is confined chiefly to the districts of Pumpkin Buttes in southwest Campbell County and Southern Powder River Basin in northwest Converse County (see Map 10, Appendix A). It is assumed that uranium activity will continue to increase through 1990.

There are presently three operating uranium mining operations (a mining project may involve several pits or underground mines, owing to the frequent occurrence of uranium in small diffuse ore bodies) and two mills in the region with two other mines nearing completion. It is anticipated that there will be four mining operations by 1980, producing a total of 3,500 tons per day (TPD) of uranium ore. In 1985, six mining operations will be producing 7,500 TPD, while in 1990, the six operations will be producing 9,500 TPD. Three uranium mills will be operational in 1980, while in 1985 and 1990, four mills will be operating.

Developments proposed to be operational by 1980 would result in employment of approximately 750 workers for uranium mining and milling activities. Uranium employment is projected to reach 1,500 by 1985 and then 2,000 by 1990. It is anticipated that 5,000 total acres will be disturbed by uranium activity by 1980, 9,500 by 1985, and 11,000 by 1990. By 1985, 3,000 acres will be reclaimed, and by 1990, 5,500 acres will be reclaimed. It is anticipated that the majority of development activity will occur in the Southern Powder River Basin (Tennessee Valley Authority 1976; Kerr-McGee, July 1977; United Nuclear 1977; Nuclear Regulatory Commission 1977; Bickert et al. *1976; Engineering and Mining Journal,* December 1975).

Other Construction Activities. Tri-County Electric Association, Inc. plans to construct a 59-mile, 230-kv transmission line from the Wyodak Power Plant east of Gillette to a site on the Campbell-Converse county line. Then, approximately 15 miles of existing transmission line originating from the Dave Johnston Power Plant near Glenrock will be extended north by Pacific Power and Light Company, requiring about 28 miles of new construction to connect with the Tri-County Electric portion. The purpose of the combined 87 miles of new transmission line and associated facilities is to improve the delivery of power for present and anticipated demands of the coal, uranium, and oil and gas industries. Construction may be under way by 1980 (personal communication, Royce Harbicht 1977).

Municipal development in the region is under way, some of which will extend beyond 1980. The community of Wright is expected to increase by an average of 200 housing units per year for 10 years (personal communication, Bob Huff 1977).

Coal Slurry Pipeline

There is a proposal by Energy Transportation Systems, Inc. (ETSI) to construct a 1,378-mile, 38-inch pipeline to export 25 million tons of coal annually from the region to Arkansas, Louisiana, Mississippi, and Oklahoma in the form of a coal-water slurry (ETSI 1978). ETSI has had an inadequate application for right-of-way for the slurry pipeline on file with the Bureau of Land Management and the U.S. Forest Service since 1974. An application adequate under Title V of the Federal Land Policy and Management Act of 1976 has not yet been filed.

Since detailed information has not yet been filed by ETSI, analysis of the cumulative impacts of the proposed pipeline are not included in this ES. After adequate applications and detailed project data have been filed, and after a lead federal agency is designated, the ETSI coal slurry project will be analyzed in a separate environmental analysis.

THE SITE-SPECIFIC ACTION

The site-specific portion of this ES analyzes the impacts of the specific authorization under consideration by the Department of the Interior. That authorization is approval of the mining and reclamation plan for the Buckskin Mine. No federal rights-of-way are required as part of this action. The site-specific action is also included as a part of the probable level of development.

In May 1977, Shell Oil Company submitted the Buckskin mining and reclamation plan, in conformance with federal regulations 30 CFR 211 (May 1976) to the Area Mining Supervisor, USGS. The plan outlines a surface coal mining operation on federal lease W-0325878, involving 600 acres (all private surface). The mine would be located approximately 10 miles north of Gillette, Wyoming, and would produce 4 million tons per year by 1990 to supply steam-powered generating facilities in Oklahoma. The mining area of operations or permit area is 1,760 acres, which includes the federal coal lease, a 1,000-foot operational perimeter around the lease, and the access and rail corridors.

Additional information from the Buckskin Mine plan is summarized by the first line entry of Table R1-2.

Required Authorizations for the Site-Specific Action

Assistant Secretary of Energy and Minerals

The Assistant Secretary shall approve the mining permit application (including the mining and reclamation plan) and significant modifications or amendments thereto prior to commencement of mining operations by the company.

Office of Surface Mining (OSM)

OSM, with the concurrence of the surface-management agency (Bureau of Land Management) and USGS, recommends approval or disapproval of the mining and reclamation plan to the Assistant Secretary of Energy and Minerals. Whenever a state has entered into a state-federal cooperative agreement with the Secretary of the Interior, pursuant to Section 523(c) of the Surface Mining Control and Reclamation Act (SMCRA), the state regulatory authority and OSM will jointly review mining and permit applications. Both agencies will recommend approval or disapproval to the officials of the state and Department of the Interior authorized to take final actions on the permit.

Bureau of Land Management (BLM)

BLM develops special requirements to be included in the reclamation plan concerning management and protection of all resources other than coal and the postmining land use of the affected lands. BLM is also responsible for granting various rights-of-way for ancillary facilities on public lands.

U.S. Geological Survey (USGS)

USGS is responsible for development, production, and coal resource recovery requirements included in the mining permit.

State of Wyoming, Department of Environmental Quality (DEQ)

Whenever Wyoming enters into a cooperative agreement with the Secretary of the Interior, pursuant to Section 523(c) of SMCRA, DEQ and OSM will jointly review and act on the mining and reclamation plan and permits to mine authorized under a federal coal lease.

The Land Quality Division of DEQ issues permits and licenses to mine according to the approved mining and reclamation plan. The Air Quality Division issues permits for construction and operation after review of applications with regard to air contaminants and plans for control and monitoring. The Water Quality Division issues permits to construct water systems. The Solid Waste Division issues construction fill permits and industrial waste facility permits for solid waste disposal during construction and operation.

Wyoming State Engineer

Water rights for the mining and coal-processing operations are required from the State Engineer. The State Engineer also must authorize proposed water diversions and impoundments.

FUTURE REVIEWS

Future National Environmental Policy Act Review Points

Future coal-related actions beyond those proposed and analyzed in this ES may require additional assessment of environmental impacts. Such future actions may include:

1. Mine and reclamation plan approval for development of existing federal coal leases.
2. Major mine and reclamation plan modifications for existing operations. Specifically, existing mines must modify their mining and reclamation plans to come into compliance with the Surface Mining Control and Reclamation Act.
3. Issuance of coal exploration licenses.
4. Future proposals for development of unleased federal coal.
5. Replacement (exchange) of leased federal coal with other federal coal in areas of high environmental cost, such as alluvial valley floors.
6. Permit and/or lease readjustments. Terms and conditions of federal coal leases are readjusted every 20 years, while mining permits are issued not to exceed 5 years, under conditions of the Surface Mining Control and Reclamation Act.
7. Federal authorizations for transportation and communication rights-of-way or other mine-related facilities.
8. Federal authorizations for plant facilities and transport systems for any major new industrial project.

Related Reviews

Preference Right Lease Application Status Review

Recent interpretation of the Mineral Leasing Act of 1920 by the Office of the Solicitor, Department of the Interior, has determined that areas of federal coal under preference right lease application (PRLA) cannot be leased if, prior to issuance of the prospecting permit, there had existed, on that area, an existing mining claim under the Mining Act of 1872. This interpretation would affect only the portion of the PRLA under mining claim. Preference right lease applicants were required to submit abstracts of any mining claims on their application to BLM by March 1978.

Preference right lease applicants were required by 43 CFR 3520 to prepare and submit initial showings indicating evidence of commercial quantities of coal to BLM by July 1977. As the PRLAs are processed, initial showings will be evaluated in technical reports and environmental assessments to be prepared jointly by BLM, OSM, and USGS.

On September 27, 1977, under order of the District Court for the District of Columbia in *National Resource Defense* Council v. *Hughes*, the Department of the Interior was enjoined from issuing any new coal leases until a supplemental coal programmatic environmental statement correcting the deficiencies of the original statement has been issued in final form and a new coal management program has been developed.

Department of Energy (DOE)

Under the Department of Energy Organization Act of 1977 (PL 95-91), DOE was authorized to set coal production rates on federal coal leases, review and concur on stipulations included in federal coal leases, and establish diligence requirements for development of each lease. Guidelines and procedures are being developed for coordination of DOE's responsibilities with those of the Department of the Interior.

ANALYSIS GUIDELINES FOR THE PROBABLE LEVEL OF PRODUCTION

An analysis of impacts requires establishing guidelines for coal-related development. The following narrative and tables were developed to establish such guidelines for coal development and other concurrent regional development activities. Probable cumulative regional development activity for the Eastern Powder River Basin is shown in Table R1-3. As new development information

TABLE R1-3

CUMULATIVE DEVELOPMENT DATA FOR THE REGION
PROBABLE LEVEL OF DEVELOPMENT

	1978	1980	1985	1990
Coal Mining				
Number of Coal Mines*	11	15	15	15
Coal Mine Support Facilities:				
Miles of Rail Spurs	41	60	60	60
Miles of Telephone Lines	34	50	50	50
Miles of Access Roads	11	22	22	22
Miles of Conveyor System	0	7	7	7
Miles of Power Lines	76	93	93	93
Coal Related Development				
Number of Power Plants	2**	2***	2***	2***
Number of Gasification Plants	0	0	1****	1
Miles of Railroad Line				
Main Line (Common-carrier)	26	113	113	113
Private	0	0	40	40
Uranium				
Cumulative Number of Mining Projects	3	4	6	7
Cumulative Number of Uranium Mills	2	3	4	4
Oil and Gas				
Area of Activity (Acres)	4,800	4,880	5,110	5,250
Other				
Miles of New 230-kv Transmission Lines	0	0	87	87
Population Increase (1,000's)*****	0	4	18	22

Note: 1978 base, and based on mining and reclamation plans and indicated trends.
* Counts East Gillette and Kerr McGee #16 individually.
** Dave Johnston and Neil Simpson.
*** Wyodak and Dave Johnston. Neil Simpson dismantled and incorporated into Wyodak.
**** Under Construction.
***** Centaur Management Consultants, Inc. 1978. Based on State of Wyoming projection model for Campbell and Converse counties: population increases represent increase over 1978 base population (25,000).

becomes available these guidelines can be utilized to reflect the changes.

Guidelines

The following information was used for analysis of impacts:

1. Cumulative impacts are analyzed for three time points (1980, 1985, 1990).
2. Reclamation schedules vary for each mine. Normally reclamation is conducted as an ongoing program. After a surface mining operation has been in progress for 2 to 3 years, the reclamation of the mined land is accomplished at approximately the same annual rate as acreage disturbance.
3. Reclamation on an area is considered complete when disturbed lands have been backfilled, graded, contoured, and revegetated in accordance with an approved reclamation plan, and bond has been released (Wyoming Land Quality Rules and Regulations 1975, Surface Mining Control and Reclamation Act of 1977).
4. Since telephone lines are usually built within access road or railroad rights-of-way, no additional acreage of disturbance has been attributed to these installations.
5. Any impacts lasting after closure of mine and release of bond will be considered long term.
6. Acreage and water requirements used to analyze cumulative impacts are derived in Tables R1-3, R1-4, R1-5, and R1-7. Tables R1-6 and R1-8 summarize acreage and water requirements.

TABLE R1-4

ACREAGE REQUIREMENTS FOR DEVELOPMENT

Facility	Average Acres Required
Mine Surface Structures (coal and uranium)	100 per mine
Uranium Mill	500 per mill
Transmission Line (230-kv)	18 per mile
Power Line	6 per mile
Telephone Line*	0 per mile
Railroad Line (157-foot right-of-way)	21 per mile
Gasification Plant (includes pipelines, power, and access)	1,500 per plant
Power Plant	2 per megawatt
Population Increase	100 per 1,000 people
Conveyor System	10 per mile
Road (100-foot right-of-way)	12 per mile
Road (2 lane, 175-foot right-of-way)	21 per mile

* Assumed either within road, rail, or power right-of-way corridor.

TABLE R1-5

SUMMARY OF CUMULATIVE ACREAGES DISTURBED AND RECLAIMED BY COAL MINING ACTIVITY
PROBABLE LEVEL OF DEVELOPMENT

		Cumulative Acreage		
	1978	1980	1985	1990
Surface Mines Operations	2,700	4,733	12,934	19,106
Power Lines	455	558	558	558
Rail Spurs	861	1,260	1,260	1,260
Access Roads	132	264	264	264
Conveyor Systems	0	70	70	70
Mine Structures	1,139	1,500	1,500	1,500
Relocations	36	36	36	36
Totals: Acres Disturbed	5,323	8,421	16,622	22,794
Acres Reclaimed	1,301	3,495	9,887	12,666
Difference	4,022	4,926	6,735	10,128

TABLE R1-6

CUMULATIVE ACREAGE DISTURBED AND RECLAIMED BY REGIONAL DEVELOPMENT ACTIVITIES
PROBABLE LEVEL OF DEVELOPMENT

	1978	1980	1985	1990
Acreage Disturbed				
Coal Mining Activity*	5,323	8,421	16,622	22,794
Power Plants	2,000	2,000	2,000	2,000
Coal Gasification	0	0	1,500	1,500
Railroad Line				
Main Line	546	2,373	2,373	2,373
Private	0	0	840	840
Uranium	4,000	5,000	9,500	13,000
Oil and Gas	4,800	4,880	5,110	5,250
Sand, Gravel, Scoria	200	200	620	1,280
230-kv Transmission Line	0	0	1,566	1,566
Population**	0	400	1,800	2,200
TOTAL	16,869	23,274	41,931	52,803
Acreage Reclaimed				
Coal Mining Activity*	1,301	3,495	9,887	12,666
Other Activities	400	1,400	3,550	6,300
TOTAL	1,701	4,895	13,437	18,966
Difference	15,168	18,379	28,494	33,837

* From Table R1-5.
** Acreage required for population increase over 1978 base municipal acreage.

TABLE R1-7

WATER REQUIREMENTS FOR DEVELOPMENT

Facility	
Per 1,000 Population Increase (urban)	190 A-F per year*
Mine Operation	20 A-F per million tons coal
Gasification Plant (270 Million cubic feet per day)	7,000 A-F
Power Plant (water-cooled)	10 A-F per megawatt
Power Plant (air-cooled)	0.4 A-F per megawatt
Uranium Operation	25 A-F per 1,000 tons of ore per day production
Uranium Mill	1,000 A-F per 1,000 tons of ore per day capacity

* Based on present water use in Gillette. A-F = acre-feet.

TABLE R1-8

INCREASED WATER USAGE FOR THE REGION
PROBABLE LEVEL OF DEVELOPMENT

Annual Water Requirements (acre-feet)

Type of Use	1975	1978	Inc.*	1980	Inc.*	1985	Inc.*	1990	Inc.*
Coal Mines	170	1,000	830	2,200	2,030	3,400	3,230	3,500	3,330
Irrigation	10,000	10,000	0	10,000	0	10,000	0	10,000	0
Municipal**	3,990	6,650	2,660	7,980	3,990	9,880	5,890	10,260	6,270
Oil Field (water-flood)	12,000	12,000	0	12,000	0	12,000	0	12,000	0
Uranium Mines	80	240	160	320	240	480	400	560	480
Uranium Mill	500	2,000	1,500	3,500	3,000	7,500	7,000	9,500	9,000
Power Plants***	7,500	7,630	130	7,630	130	7,630	130	7,630	130
Gasification Plant	---	---	---	---	---	7,000	7,000	7,000	7,000
Stock Water and Domestic	10,000	10,000	0	10,000	0	10,000	0	10,000	0
Totals	44,240	49,520	5,280	53,630	9,390	67,890	23,650	70,450	26,210
Sewage**** (Estimate of Water Used)	2,800	4,600	1,800	5,600	2,800	6,900	4,100	7,200	4,400

* Increase over base year (1975).
** Includes need for projected population increase in region.
*** Includes Wyodak air-cooled and Dave Johnston water-cooled plants.
**** Not a part of cumulative total.

CHAPTER 2

DESCRIPTION OF THE ENVIRONMENT

INTRODUCTION

This chapter consists of two parts: existing environment and future environment. It describes the physical, biological, and cultural factors which constitute the environment within the Eastern Powder River Basin of Wyoming, the region of analysis for this coal environmental statement (ES). The description of the existing environment updates information in the 1974 Regional ES (FES 74-55);* it emphasizes those environmental factors most likely to be affected by the site-specific action and other possible future federal coal development. The description of the future environment discusses changes in the existing environment projected to occur by 1980, 1985, and 1990, without approval of the Buckskin Mine, which is the proposed action in the site-specific portion of the ES. Taken together, these descriptions provide the background for the analysis in Chapter 4, "Environmental Impacts of Regional Development,"since some alteration of these environmental elements would result if the site-specific action is approved, along with the continuation of development already underway or pending approval.

CLIMATE

Introduction

The climate of the region is typical of mid-latitude semiarid areas, with cold winters and warm summers (Trewartha, 1961). The terrain is rolling and hilly. The mountain ranges that most affect the atmospheric flow over the Eastern Powder River Basin are the Big Horn Mountains to the west and the Black Hills to the east. Because the region is east of the Rockies and at a high elevation, little precipitation falls (normally about 14 inches per year). Most of the region's precipitation falls from air masses that originate over the Pacific Ocean, but some precipitation results from incursions of moist air from the Gulf of Mexico.

Variations in weather are generally related to extratropical low pressure systems that travel from west to east through the region. These large-scale meteorological systems can cause considerable snowfall during the winter and can generate strong surface winds.

Specific Climatic Factors

Temperature

Average temperatures do not vary greatly over the region since elevation differences are relatively small. In general, the temperature is lower at the higher elevations. However, lower elevations such as valleys can become cooler than nearby higher elevations because of cold air drainage, which results from strong radiational cooling. The most pronounced radiational cooling occurs on clear, calm nights.

The region is sometimes affected by chinook winds, which are warm winds that sweep down the eastern slopes of the mountain ranges to the west of the region. These winds usually blow from the direction of the Big Horn Mountains and sometimes blow from the other mountain ranges that lie farther to the west and southwest.

The warmest month of the year is July with daily maximum temperatures often 90°F or above, although maximum temperatures average in the upper 80s. January is the coldest month of the year with frequent daily minimum temperatures of 0°F or below (National Oceanic and Atmospheric Administration 1974). The monthly and annual average temperatures in or near the region are presented in Table R2-1.

Growing Season

The growing season is the number of consecutive days with temperatures higher than a specified value. Areas of high elevation and areas where cold air drainage occurs experience the shortest growing seasons. Locations at intermediate levels tend to experience the longest growing seasons. Drainage basins experience a higher frequency of frost than areas immediately outside the basins since cold air drains into the basins during the night and early morning hours. The length of the growing season at a particular locality is variable from year to year, depending on large-scale meteorological conditions. Some species of plants are vulnerable to light freezes while others are affected only by hard freezes. The average growing seasons for various stations in eastern Wyoming for temperatures of 32°F, 28°F, 24°F, 20°F, and 16°F are shown in Table R2-2.

The date of the first fall freeze is of particular importance in attempting to revegetate disturbed areas. The objective of revegetation is to establish a self-sustaining

TABLE R2-1

AVERAGE TEMPERATURE DATA (^{o}F) FOR SELECTING LOCATIONS IN OR NEAR THE EASTERN POWDER RIVER BASIN

Month	Gillette 2E*	Dull Center 1SE*	Casper	Midwest	Rockypoint 2NE*
January	21.9	23.6	22.3	24.0	19.2
February	25.0	26.5	25.9	27.3	22.1
March	30.9	32.8	32.4	33.9	28.7
April	43.3	44.7	43.0	45.2	42.5
May	52.9	54.3	53.1	54.6	52.7
June	61.3	63.7	62.0	64.0	61.4
July	72.2	73.4	71.1	73.3	71.4
August	70.2	70.7	68.9	71.2	69.7
September	59.9	60.4	58.1	61.1	58.9
October	48.7	48.6	46.4	49.9	47.3
November	33.8	34.5	33.3	35.3	31.7
December	26.1	26.3	25.5	27.8	23.3
Annual	45.5	46.6	45.1	47.3	44.1

Source: National Oceanic and Atmospheric Administration 1974.
Note: Averages are based on data for the period 1931-1955.
* Number of miles and direction that the station is located away from the main post office.

TABLE R2-2

GROWING SEASON DATA FOR THE EASTERN HALF OF WYOMING INCLUDING THE EASTERN POWDER RIVER BASIN
(BASED ON PERIOD FROM 1921-1950)

STATION	ELEVATION	Average Number of Days Between the Last Spring Occurrence and the First Fall Occurrence of Indicated Temperature (°F)					Average Dates of First Occurrence in the Fall of the Indicated Temperatures (°F)					Average Dates of Last Occurrence in the Spring of the Indicated Temperatures (°F)				
		32°	28°	24°	20°	16°	32°	28°	24°	20°	16°	32°	28°	24°	20°	16°
Casper*	5,322	130	150	174	192	209	9/25	10/2	10/15	10/22	10/28	5/18	5/5	4/24	4/13	4/2
Cheyenne*	6,139	130	149	169	189	213	9/27	10/4	10/15	10/25	11/5	5/20	5/9	4/30	4/19	4/6
Chugwater	5,282	102	127	150	172	187	9/13	9/22	10/3	10/12	10/19	6/3	5/17	5/6	4/24	4/15
Dull Center**	4,354	125	147	167	192	209	9/20	9/30	10/10	10/22	10/30	5/19	5/6	4/27	4/13	4/4
Gillette**	4,602	129	150	174	193	207	9/27	10/4	10/15	10/23	11/1	5/21	5/7	4/24	4/13	4/8
Kaycee	4,660	110	134	158	175	198	9/17	9/26	10/5	10/10	10/20	5/30	5/15	4/30	4/18	4/5
Kirtley	5,200	115	140	161	178	195	9/21	9/28	10/10	10/19	10/27	5/29	5/11	5/2	4/24	4/15
La Grange	4,720	120	142	167	185	201	9/21	10/1	10/11	10/20	10/28	5/24	5/12	4/27	4/17	4/10
Leo***	6,000	84	129	153	172	195	8/30	9/26	10/3	10/14	10/24	6/7	5/20	5/3	4/25	4/13
Laramie	7,211	113	135	159	176	193	9/19	9/28	10/10	10/20	10/26	5/29	5/16	5/4	4/27	4/16
Lookout***	6,969	96	125	150	163	181	9/7	9/23	10/2	10/10	10/20	6/3	5/21	5/5	4/30	4/22
Marshall***	7,010	60	83	122	144	166	8/18	9/1	9/22	10/1	10/10	6/20	6/10	5/22	5/11	4/27

TABLE R2-2
(cont'd)

GROWING SEASON DATA FOR THE EASTERN HALF OF WYOMING INCLUDING THE EASTERN POWDER RIVER BASIN
(BASED ON PERIOD FROM 1921-1950)

STATION	ELEVA-TION	Average Number of Days Between the Last Spring Occurrence and the First Fall Occurrence of Indicated Temperature (°F)					Average Dates of First Occurrence in the Fall of the Indicated Temperatures (°F)					Average Dates of Last Occurrence in the Spring of the Indicated Temperatures (°F)				
		32°	28°	24°	20°	16°	32°	28°	24°	20°	16°	32°	28°	24°	20°	16°
Metz Ranch	5,280	121	143	169	187	208	9/19	9/30	10/8	10/21	10/30	5/20	5/11	4/22	4/17	4/5
Newcastle	4,480	137	156	183	198	214	9/29	10/8	10/20	10/27	11/3	5/15	5/5	4/20	4/11	4/3
Pine Bluffs	5,044	124	146	171	191	204	9/21	9/29	10/14	10/23	10/29	5/20	5/7	4/27	4/15	4/7
Rockypoint***	4,100	123	141	165	186	204	9/22	9/30	10/11	10/21	10/29	5/22	5/13	4/29	4/18	4/8
Ross**	5,250	110	146	164	180	196	9/15	9/30	10/7	10/15	10/22	5/27	5/7	4/26	4/18	4/9
Saratoga	6,786	80	112	137	162	183	8/29	9/16	9/27	10/9	10/21	6/10	5/26	5/14	4/29	4/21
Sheridan Field Station	3,800	123	150	181	198	211	9/21	10/1	10/18	10/26	11/1	5/21	5/4	4/20	4/11	4/4

Source: National Oceanic and Atmospheric Administration 1974, U.S. Department of Commerce (October 1989-1975).
* Station located at airport.
** Denotes station within study area.
*** Number of miles and direction that the station is located away from the main post office.

vegetative cover (Atlantic Richfield Company 1977). To ensure survival during the winter, seedlings of grass, shrubs, or trees that are used for revegetation may need to be mature before the first day with a freezing or subfreezing temperature. The end of the growing season for 32°F typically occurs during the second half of September. For a 24°F criterion, the growing season ends during the first half of October, while for 16°F the growing season ends during the second half of October.

Precipitation

Total Precipitation. The precipitation totals (rainfall plus the water equivalent of snowfall) in the Eastern Powder River Basin are relatively low compared to the totals in other areas of the United States. The monthly precipitation is highest in May and June, and lowest in December, January, and February. The Eastern Powder River Basin averages 12 days of measurable precipitation during May, and only 5 days during October (National Oceanic and Atmospheric Administration 1974). The total monthly and annual precipitation for Gillette and Dull Center are listed in Table R2-3. The precipitation pattern for the region shown in Figure R2-1 is based on data from numerous cooperative stations.

Snowfall. Snowfall within the Eastern Powder River Basin varies with elevation. The highest annual average snowfalls of over 70 inches are experienced in the areas west of Gillette and south of Douglas. The lowest annual snowfalls measure less than 30 inches and occur in the extreme northwestern and northeastern corners of the region and near Highland Flats in the southern portion (U.S. Department of Commerce 1974-1975). The snowfall season over northeastern Wyoming lasts nearly 10 months, from September to June. The maximum monthly snowfall normally occurs in March.

Areas of high annual snowfall shown in Figure R2-2 are not necessarily areas having the heaviest annual precipitation. In some cases snow falls over higher elevations, while rain falls over the lower elevations as a result of higher temperatures at the lower elevations.

Snowfall intensities are generally not excessive throughout Wyoming. Usually about five times a year, stations at lower elevations record single-storm snowfalls in excess of 5 inches. Occasionally, 10 to 15 inches of snow may fall from one storm, but such amounts of snow are unusual outside the mountainous regions (National Oceanic and Atmospheric Administration 1974).

Heavy Rainfall Events. The heaviest theoretical rainfalls for the United States have been calculated using real data as input for mathematical rainfall models (Hershfield 1961). These calculations indicate that any point in the Eastern Powder River Basin has a 100-year mean recurrence interval for a rainfall rate of 1.7 inches in a 30-minute period. Rainfalls of this intensity occur at an average frequency of once every 100 years. Similarly, 24-hour rainfalls of 4.0 inches can be expected once every 100 years.

Climatological records indicate that the heaviest 24-hour precipitation total ever recorded in Wyoming occurred at Dull Center (in the region). This record precipitation amount was 5.50 inches on May 31, 1927 (National Oceanic and Atmospheric Administration 1974).

Floods. Occasionally flooding occurs in the region. Normally, any flooding coincides with the spring snow melt. When the melting of the snowpack coincides with heavy rains, the region experiences its most severe flooding.

Droughts. Historical data indicate a 1-year drought frequency of once every 7 years, a 2-year drought frequency of once every 25 years, and a 3-year drought frequency of once every 143 years. These results were derived from statistical analysis of long-term data for Douglas, Gillette, and Dull Center. Probabilities and mean recurrence intervals (average frequencies) were calculated for 1 year, 2 consecutive years, and 3 consecutive years with 75% of normal annual precipitation.

The frequency of droughts is an important consideration in the determination of revegetation success. Annual rainfall totals can be used as general indicators of drought conditions. Since hydrological imbalances denote drought conditions, subnormal precipitation totals can indicate probable drought conditions that may cause failure of revegetation attempts. Drought conditions may develop whenever a certain location receives less than 75% of its normal precipitation (Texas Almanac 1975).

Thunderstorms, Hailstorms, Tornadoes. Locations in the Eastern Powder River Basin are likely to experience 38 days a year on which thunderstorms occur (Landsberg 1969). In comparison, the most thunderstorm days in Wyoming, 45 per year, occur over the southeastern portion, while the northwestern portion of the state has only 35.

Ten percent of the thunderstorms in the region may produce hail (Flora 1956). Hail in the region is not unusual. The region experiences hail 3 days per year in the northern and southern portions and 2 days per year in the central portion (Changnon 1977). The hailstorms in Wyoming are most frequent between 2:00 p.m. and 3:00 p.m. in June and July.

Tornadoes are not very frequent and are usually rather small. The probability and average frequency for a tornado to strike any given point in the Eastern Powder River Basin were calculated from tornado occurrence records (U.S. Department of Commerce 1969) and by a prescribed method (Thom 1963). A tornado can be expected at any given point in the region only once every 3,000 years. In contrast, a point in central Oklahoma can be expected to suffer the effects of a tornado once every 275 years.

Air Moisture Statistics

The annual average relative humidity ranges from 55% to 60% over the region. The most humid months are usually November, December, and January, during which the relative humidities average 65% to 70%. The lowest monthly average relative humidity occurs in August when the daily relative humidities average only 45% to 50%. Generally, relative humidities are highest near sunrise, when the coolest temperatures normally occur, and lowest in mid-afternoon, when the tempera-

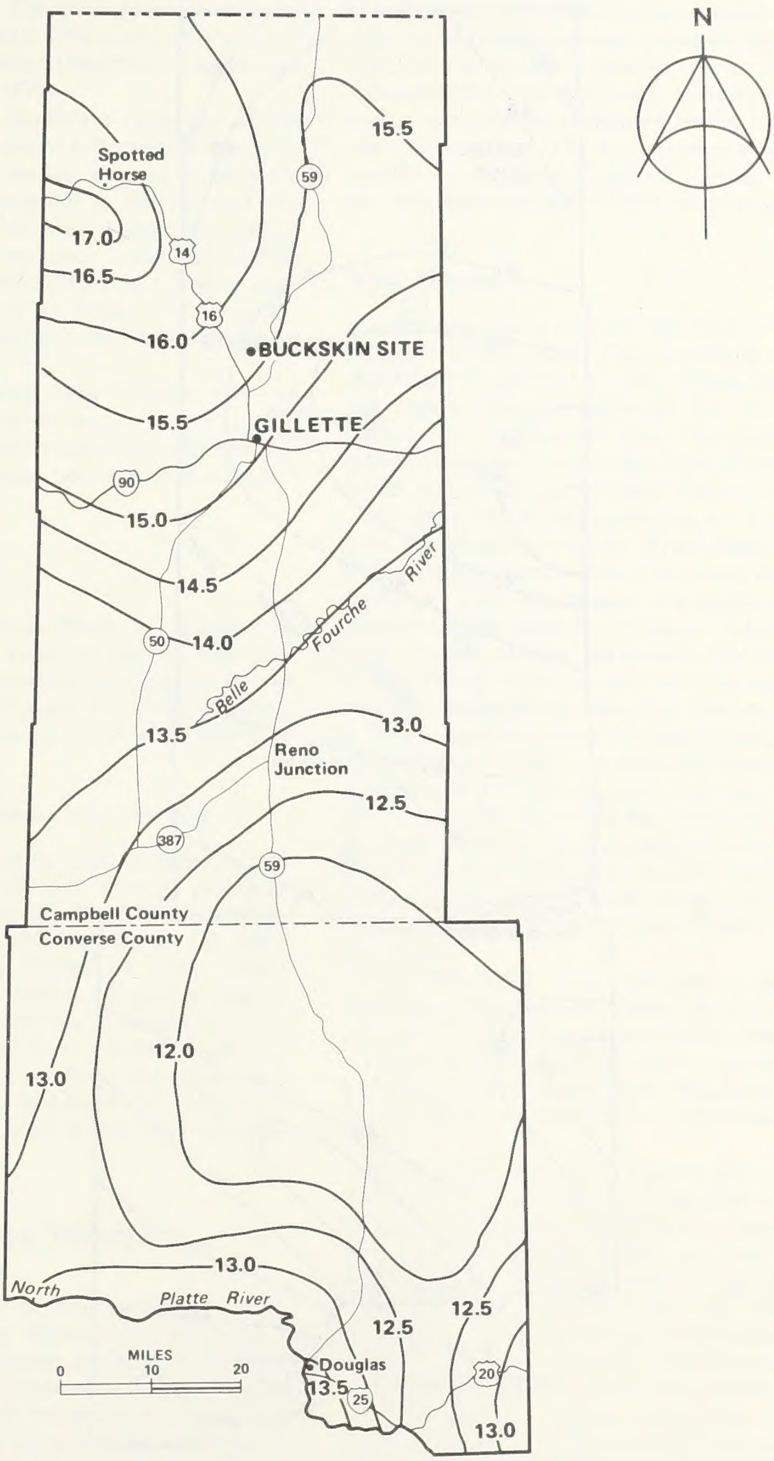
TABLE R2-3

REPRESENTATIVE MONTHLY AND ANNUAL PRECIPITATION NORMALS FOR THE EASTERN POWDER RIVER BASIN (1931-1955)

(Inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Gillette	0.70	0.50	1.15	1.71	2.31	2.51	1.27	0.86	1.17	0.72	0.73	0.64	14.27
Dull Center	0.27	0.27	0.55	1.55	2.37	2.24	1.45	1.47	0.98	0.88	0.42	0.29	12.74

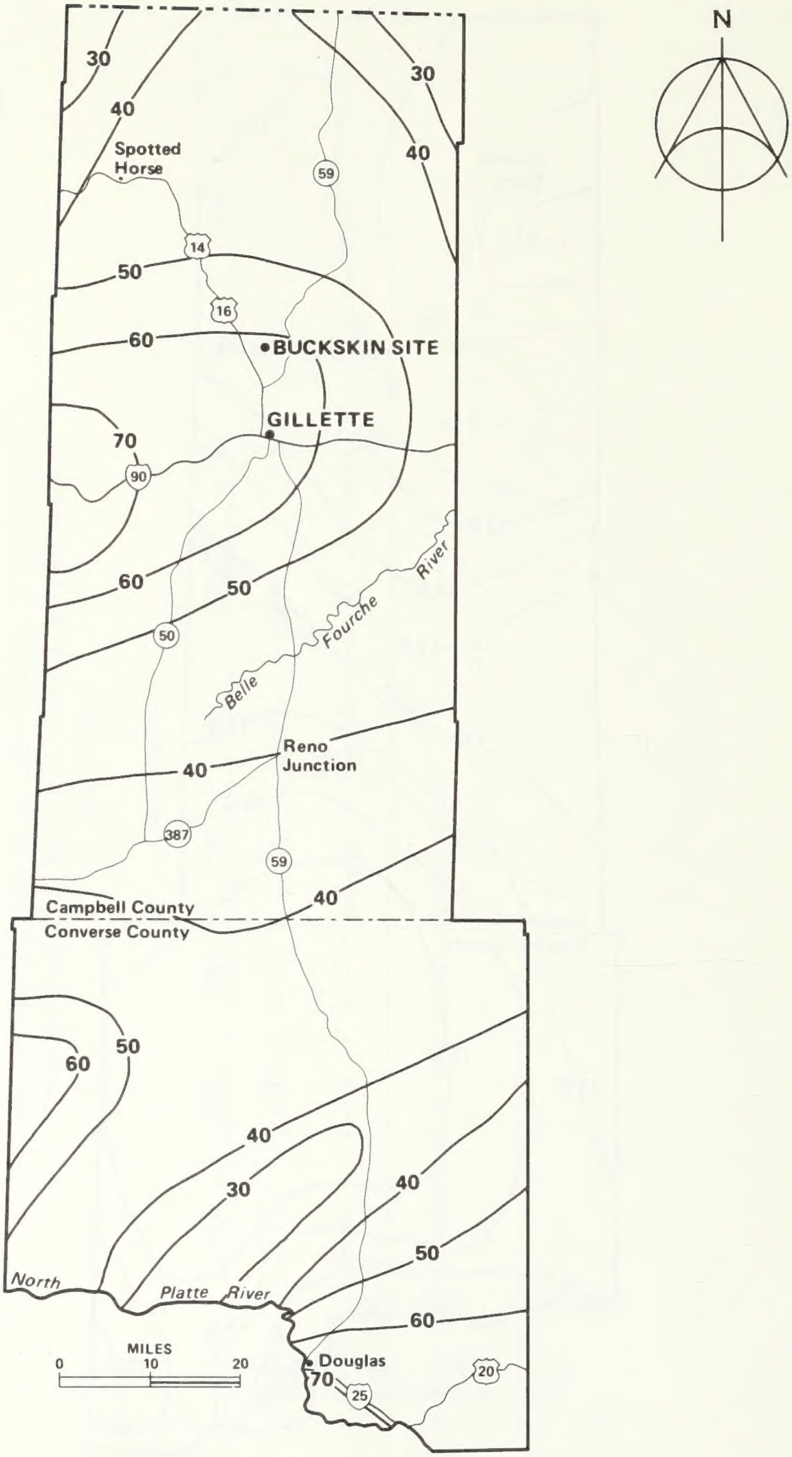
Source: National Oceanic and Atmospheric Administration 1974



SOURCE: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 1974. UNITED STATES DEPARTMENT OF COMMERCE, 1955 - 1975

Figure R2-1

ANNUAL PRECIPITATION TOTALS IN INCHES, 1931 - 1975



SOURCE: UNITED STATES DEPARTMENT OF COMMERCE, 1954 - 1975.

Figure R2-2
ANNUAL SNOWFALL IN INCHES, 1954 - 1975

tures are usually the highest. The average daily range of relative humidities is from about 45% in the afternoon to about 70% in the early morning (National Oceanic and Atmospheric Administration 1974).

Fog does not often cause significant reduction of the visibility in the region. Fogs occur infrequently in northeastern Wyoming because of the low amount of moisture normally available for condensation in the air near the ground. Depending on the location within the region, there are 5 to 10 days a year on which horizontal visibilities of ¼ mile or less are reported (National Oceanic and Atmospheric Administration 1974). Fogs occur most frequently during the spring and fall and least frequently during the summer.

The mean annual evaporation from a large body of water, such as a lake, is about 42 inches in the region. The mean annual Class A pan evaporation rate for the region is approximately 60 inches per year (U.S. Department of Commerce 1968).

Sunshine

In the Eastern Powder River Basin, an average of 2,840 hours of sunshine are recorded during the year. This represents 63% of the possible sunshine during the year. The month of July receives the most sunshine while the November-December period receives the least.

Visibility Related to Precipitation, Fog, and Haze

Visibility in the region is quite good because of the dry air which prevails. The annual average visibilities range from approximately 35 to 45 miles. Visibilities average about 30 miles during the early spring and about 50 miles during the summer. Visibilities lower than 1 mile are infrequent; however, visibilities greater than 60 miles are fairly common. The primary restrictions to visibility are precipitation, fog, and haze. Visibilities are normally highest in the afternoons (1) when the relative humidity is lowest, (2) when any low-level fog or haze has dispersed, (3) when the air is well mixed, and (4) when the wind speeds are strongest.

Visibility Related to Atmospheric Particulate Concentrations

The data from measurement of total suspended particulate (TSP) concentrations by high-volume samplers is the only instrument-based indicator available to estimate horizontal visibilities. An empirical relationship between horizontal visibilities and TSP concentrations has been established by a study done at the Los Alamos Scientific Laboratory (Ettinger and Royer 1972). Applying the empirical function to the regional baseline TSP concentration of 24 micrograms per cubic meter ($\mu g/m^3$), the annual average visibility for the region is 54 miles. That is, the mean visibility is 54 miles in the areas of the region where the air quality is not affected by surface mining or by urban areas.

Visibilities of 7 miles or less caused by dust, blowing dust, or blowing sand are expected less than 1 hour per year in the Eastern Powder River Basin (Orgill and Sehmel 1976). The frequency of dusty conditions in Wyoming is negligible compared to the rest of the contiguous United States. The highest annual frequency of dusty conditions occurs at Lubbock, Texas, where 263 hours per year are expected to have dusty conditions.

Wind Patterns

An annual wind rose for Moorcroft, Wyoming, is presented in Figure R2-3. The large-scale wind patterns are significantly modified by the terrain in and surrounding the region; thus, no uniform flow exists over all the region. On a large-scale basis, the Moorcroft wind patterns are affected by the Big Horn Mountains to the west of the region and by the Black Hills to the east.

At about 10,000 feet above sea level, the wind patterns over the Eastern Powder River Basin show the wind blows predominantly from the west through northwest directions. This information was gained from upper-level meteorological data for Glasgow, Montana, and Rapid City, South Dakota (National Climatic Center 1972-1975). Those cities are the locations of the most representative atmospheric sounding stations near the region.

The annual wind rose for Moorcroft shows that south-southeasterly (SSE), south-southwesterly (SSW), and northerly (N) winds are most prevalent. This wind pattern is partially caused by the low-level blocking and deflecting of the prevailing westerlies by the Black Hills, which are east of Moorcroft. The frequent N and north-northwesterly (NNW) winds at Moorcroft are most often associated with the movement of cold air masses across the region.

The Moorcroft wind rose show approximately the same percentage of SSE winds for each of the four seasons of the year. Except for winter, SSE winds prevail. During the winter, SSW winds prevail, although SSE winds are almost as common. Winds from the combined N and NNW sectors show a predominance during the spring.

Wind speeds are often high in the region because of the vast stretches of open, unforested land. The respective annual average wind speeds at Casper, Douglas, and Moorcroft for certain periods of record are 13.1 miles per hour (mph), 12.5 mph, and 9.2 mph (National Climatic Center 1970-1974, 1948-1954, 1950-1952, respectively). Differences of annual average wind speeds among the locations are largely caused by the effects of local features of topography such as river valley orientations.

Wind speeds are highest during the winter and spring, when large-scale weather systems are strongest. During the winter, wind gusts frequently reach 30 to 40 mph, with occasional higher gusts (National Oceanic and Atmospheric Administration 1974). Winds are lightest during the summer. Once every 100 years a 95-mph sustained wind can be expected in the region, while once every 50 years an 85-mph wind can be expected (Thom 1968).

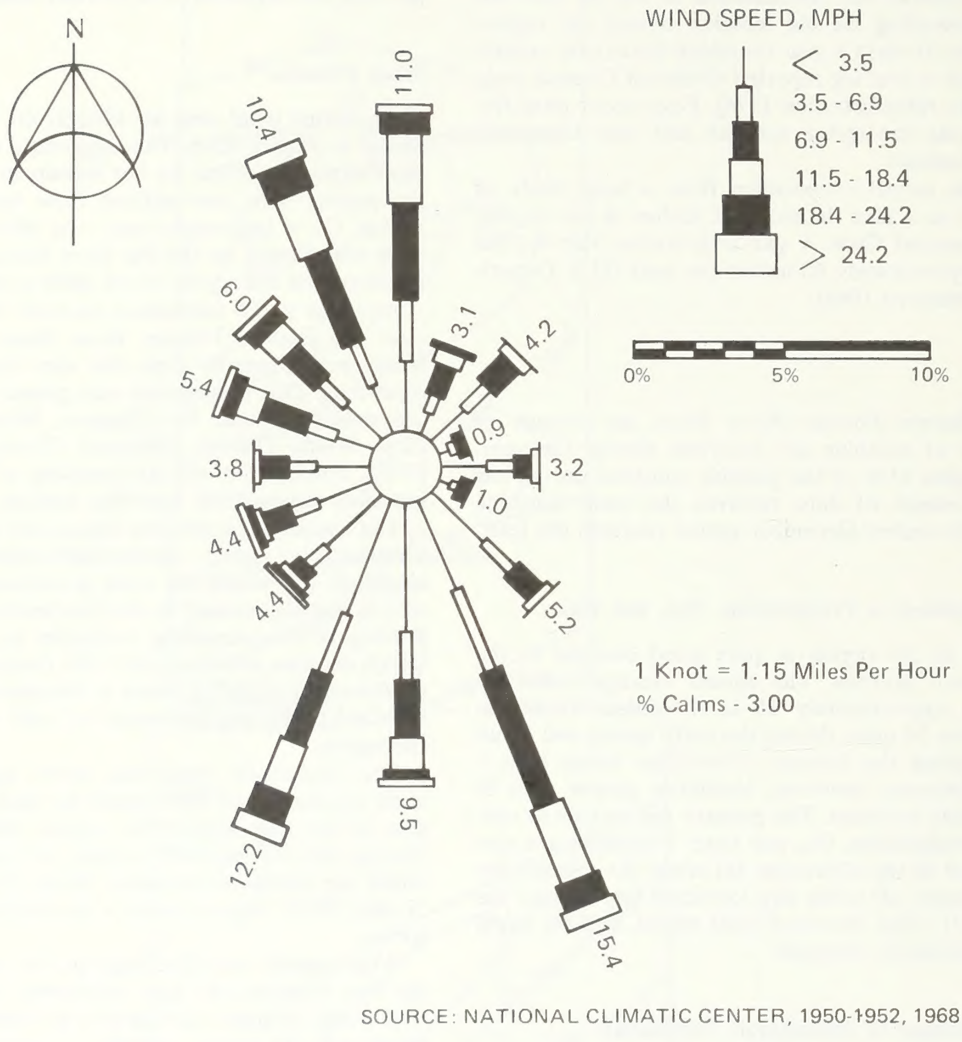


Figure R2-3
ANNUAL WIND ROSE FOR MOORCROFT, WYOMING
1950-1951

Pollution Dispersion Potential

General Characteristics

The pollution dispersion potential is an indicator of the ability of the atmosphere to disperse or dilute air pollutants and is related to air ventilation. In general, a high pollution dispersion potential (high ventilation) is desirable, since it lowers the pollution concentrations that can be expected at the ground level. The pollution dispersion potential for the Eastern Powder River Basin is somewhat worse than the average dispersion potential for the contiguous United States. Approximately two-fifths of the United States has worse dispersion potential than the region. The ventilation values in Table R2-4 show that the pollution dispersion potential is highest during the spring and summer.

Topographic Influences

Figure R2-4 shows airshed areas in the region which might represent problem areas with respect to pollution. These airsheds are often characterized by steep-sided valleys or canyons. These areas often have lighter winds and lower mixing heights than surrounding regions because of (1) the sheltering effect of the valley walls, and (2) cold air drainage down the valley slopes. The accumulation of the cold air in the valleys produces stronger, deeper, and more persistent temperature inversion layers that limit mixing of the air.

AIR QUALITY

Introduction

The 1970 Clean Air Act Amendments established primary and secondary national ambient air quality standards for six pollutants: total suspended particulates (TSP), sulfur dioxide, nitrogen dioxide, carbon monoxide, photochemical oxidants (ozone), and hydrocarbons. These standards are discussed in detail in Chapter 3. The primary standards were set to protect the public health, while the secondary standards were set to protect the public welfare.

The Eastern Powder River Basin Wyoming, Campbell and Converse counties, is meeting the national standards for all "criteria"pollutants (U.S. Environmental Protection Agency 1978). All of the Wyoming air quality standards are also being met. The prevention of significant air quality deterioration (PSD) regulations, which apply to all areas meeting the national ambient air quality standards, are applicable to the Eastern Powder River Basin. PSD regulations are further discussed in Chapter 3.

Existing Air Quality

Total Suspended Particulates

The TSP monitors used to characterize the regional air quality are listed in Figure R2-5. Monitors with less than a complete year of data are included in the table as an indicator of the 24-hour concentrations expected in portions of the region. Monitors that were sited to assess the air quality impact of specific emissions sources are not included in the table, since these monitors are not representative of the regional air quality. At a few of these monitors, the national and state standards have been exceeded (see Table R2-5). The measured TSP concentrations at Casper, Douglas, and Gillette are well below both the national and state ambient air quality standards. Annual geometric means at these urban sites range from 30 micrograms per cubic meter ($\mu g/m^3$) at Gillette to 51 $\mu g/m^3$ at Casper. These concentrations are well below the national secondary and Wyoming ambient air quality standard of 60 $\mu g/m^3$. The 10 $\mu g/m^3$ annual concentration recorded for Gillette is for a monitor at a rural site 7 miles south of town. TSP concentrations monitored at the site are not expected to be representative of the TSP concentrations of the downtown area of Gillette. Second highest 24-hour concentrations in the urban areas range from 74 $\mu g/m^3$ at Douglas to 150 $\mu g/m^3$ at Gillette. The 24-hour TSP concentration at Gillette equals the federal secondary and Wyoming ambient air quality standard of 150 $\mu g/m^3$.

The annual TSP concentrations at undeveloped rural sites are less than half of the national secondary and Wyoming ambient air quality standards. The annual TSP concentrations vary from 11 $\mu g/m^3$ at the proposed Buckskin Mine site to 29 $\mu g/m^3$ at the planned coal gasification plant site. The second highest 24-hour concentrations are also less than the standards. The second highest 24-hour concentrations range from 43 $\mu g/m^3$ at the Pronghorn Mine between Gillette and Reno Junction to 131 $\mu g/m^3$ at a site nearer Reno Junction.

Gaseous Pollutants

Sulfur dioxide (SO_2) monitoring data are available for only two towns in or near the region: Gillette and Casper. The Gillette site also has the only nitrogen dioxide (NO_2) monitor in the region. The only photochemical oxidant monitor was installed at Douglas in late 1977. Carbon monoxide is not monitored in Wyoming.

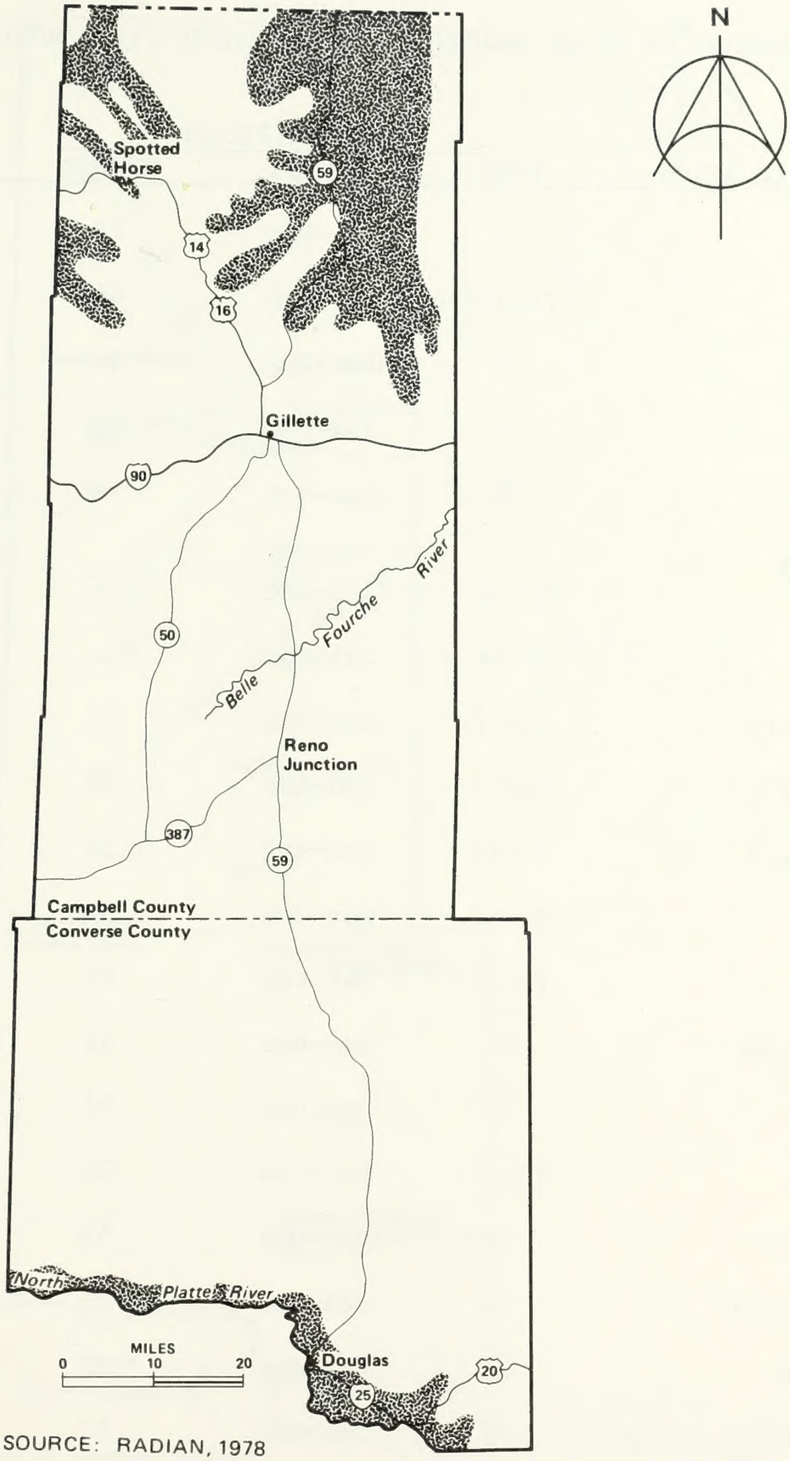
The limited SO_2 and NO_2 sampling data indicate that existing regional concentrations are low. Annual SO_2 concentrations range from 4 $\mu g/m^3$ at Casper in 1976 to 14 $\mu g/m^3$ at Gillette in 1974-1975. These concentrations are well below the 60 $\mu g/m^3$ Wyoming standard. Maximum 24-hour SO_2 concentrations were also well below the 260 $\mu g/m^3$ Wyoming standard. Gillette had a 48 $\mu g/m^3$ maximum 24-hour concentration in 1974-1975, while Casper had a 15 $\mu g/m^3$ second highest 24-hour concentration. The annual NO_2 concentration of 3 $\mu g/m^3$ meas-

TABLE R2-4

DISPERSION CONDITIONS IN THE EASTERN POWDER RIVER BASIN

Season	Mixing Height (Meters), (Feet) Morning		Afternoon		Transport Wind Speed (Meters/Second), (Miles/Hour) Morning		Afternoon		Ventilation* (Meters^2/Second), (Feet^2/Second) Morning		Afternoon	
Winter	300	984	1,000	3,281	5.8	13.0	6.8	15.2	1,740	18,729	6,800	73,195
Spring	400	1,312	2,400	7,874	6.0	13.4	8.1	18.1	2,400	25,833	10,440	209,250
Summer	300	984	2,800	9,186	4.2	9.4	6.6	14.8	1,260	13,563	18,480	198,917
Fall	290	951	1,700	5,577	4.9	11.0	7.0	15.7	1,570	16,899	11,900	128,090
Annual	320	1,050	1,090	6,234	5.2	11.6	7.1	15.9	1,720	18,514	13,490	145,205

Source: Holzworth 1972
Note: Period of Record: 1960-1964
* Ventilation equals mixing height times transport wind speed.



SOURCE: RADIAN, 1978

Figure R2-4
AIRSHEDS IN THE EASTERN POWDER RIVER BASIN

TABLE R2-5

SUMMARY OF TOTAL SUSPENDED PARTICULATES (TSP) MONITORING DATA

MONITORING LOCATION	SAMPLING PERIOD YEAR	MONTHS	NUMBER	CONCENTRATIONS ($\mu g/m^3$) AGM*	2ND MAX**
URBAN					
Gillette	75	Jan-Aug	27	IS****	150
	75-76***	Sep-Sep	64	10	46
Casper	76	Jan-Dec	54	51	156*****
Douglas	75	Jan-Dec	60	33	74
	76	Jan-Dec	--	30	NA
RURAL-NORTH					
Rawhide	75-76	Jul-Jun	--	27	81
Rawhide 2	75-76	Jul-Jun	--	18	51
East Gillette	76-77	Apr-Mar	54	18	44
Eagle Butte 1	76-77	Jun-Apr	58	IS	87
Eagle Butte 2	76-77	Jun-Apr	54	IS	71
Buckskin 1	76-77	Mar-Feb	52	11	44
Buckskin 2	76-77	Mar-Feb	55	12	44
Reno Junction	75	Jan-Dec	52	22	131
	76	Jan-Dec	54	19	90*****
Pronghorn	75-76	Dec-Jun	27	IS	43
Gordon Ranch	75	Jan-Dec	59	26	84
Stoddard Ranch	75	Jan-Jun	23	IS	30
Irene Ranch	75	Feb-Aug	23	IS	75
Panhandle E.	75	Jan-Dec	52	29	72
	76	Jan-Sep	37	IS	51

Sources: Schick undated, Radian 1977, PEDCo 1976, Metronics 1975

* AGM--Annual geometric mean (comparable to National Ambient Air Quality Standards)

** 2ND MAX--Second highest 24-hour concentration

*** Monitor moved 7 miles south of town

**** IS--Insufficient sampling period to compute AGM

***** Highest 24-hour concentration--second highest not available

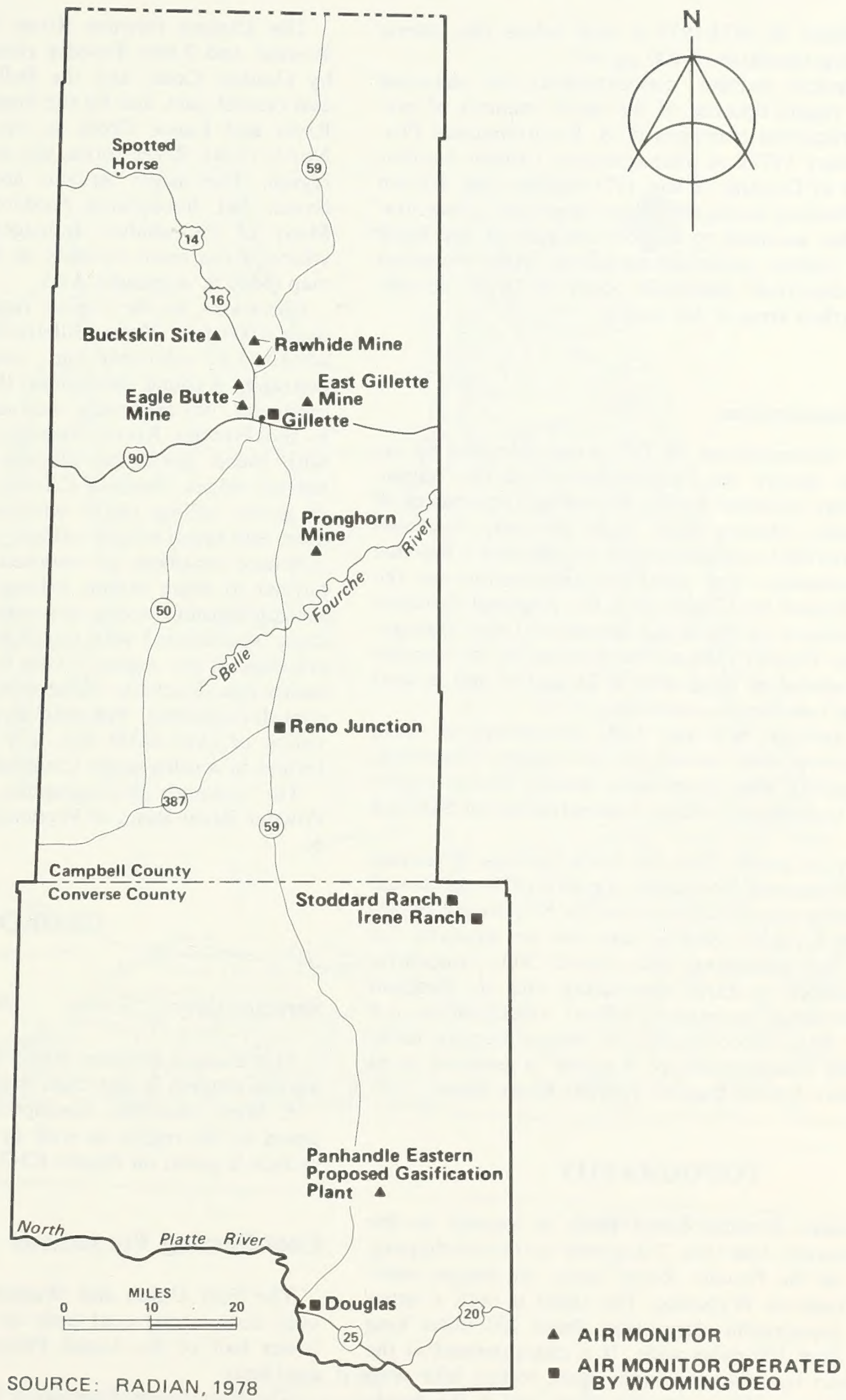


Figure R2-5
LOCATIONS OF AIR MONITORS IN CITIES AND UNDEVELOPED RURAL AREAS

ured at Gillette in 1974-1975 is well below the federal and Wyoming standards of 100 $\mu g/m^3$.

Photochemical oxidant concentrations are assumed low in the region because of the small amounts of precursor hydrocarbon emissions (U.S. Environmental Protection Agency 1977). A photochemical oxidant monitor was located at Douglas in late 1977 but the data are not available. Existing ambient carbon monoxide concentrations are also assumed to be low because of the small amounts of carbon monoxide emissions. Most violations of carbon monoxide standards occur in large, densely populated urban areas of the nation.

Baseline Concentrations

Baseline concentrations of TSP were estimated by examining air quality data representative of the region. Two monitors operated by the Wyoming Department of Environmental Quality and eight privately operated monitors provided acceptable data to calculate a baseline TSP concentration. For additional information see the Technical Report for Chapter 4 of the Regional Environmental Statement on file at the Bureau of Land Management Casper District Office. The average of the concentrations measured at these sites is 24 $\mu g/m^3$ and is used as an annual baseline concentration.

Annual average SO_2 and NO_2 concentrations were only monitored near towns in the region. Therefore, rural air quality data from areas similar to the region were used to estimate baseline concentrations of SO_2 and NO_2.

Based on air quality data for Rock Springs, Wyoming (U.S. Environmental Protection Agency 1976), an annual average background concentration for SO_2 would be approximately 3 $\mu g/m^3$. Similar data was not available for Wyoming for estimating background NO_2 concentrations. However, a rural monitoring site in Rosebud County, Montana, reported an annual concentration of 9 $\mu g/m^3$ for NO_2. Accordingly, an annual average background NO_2 concentration of 9 $\mu g/m^3$ is assumed to be representative for the Eastern Powder River Basin.

TOPOGRAPHY

The Eastern Powder River Basin is located on the gently (generally less than 2 degrees) southwest-dipping, east flank of the Powder River Basin, the largest intermountain basin in Wyoming. The latter is both a structural and topographic depression about 250 miles long and more than 100 miles wide. It is characterized in the northern part by relatively high, open, rolling hills with 500 to 1,000 feet of topographic relief, and in the southern part by plains and tablelands with moderate topographic relief of 300 to 500 feet (Keefer 1974).

The topography is controlled mainly by geology and climate. The essentially flat-lying beds of clay, silt, and sand erode easily, whereas harder beds of scoria (clinker) and massive sandstone are left as rough, hummocky escarpments, ridges, knobs, and buttes.

The Eastern Powder River Basin is drained by the Powder and Little Powder rivers in the northern part, by Donkey Creek and the Belle Fourche River in the east central part, and by the South Fork of the Cheyenne River and Lance Creek in the southeastern part. The North Platte River forms the southern boundary of the region. The larger streams are well entrenched with broad, flat floodplains bordered by alluvial terraces. Many of the smaller drainages also contain alluvium which is too small to show at the scale of the geologic map (Map 9, Appendix A).

Elevations in the region range from about 3,400 to over 6,000 feet. From Gillette north, the region is characterized by relatively high, rounded hills. Badlands topography is found throughout the area adjacent to major drainages, but especially west and northwest of Gillette in the Powder River drainage. Here narrow drainages with steep gradients (slopes) are divided by steep, narrow ridges. South of Gillette, the topography changes to gently rolling plains with occasional erosional remnants and broad stream valleys.

Where coal beds are exposed, the coal has commonly burned to some extent, baking the overlying rock into erosion-resistant scoria deposits. The most extensive of these is associated with the Wyodak seam along the eastern edge of the region, where it forms buttes and escarpments (the Rochelle Hills) marking the eastern limit of coal development. Pumpkin Buttes, which rise to an elevation of over 6,000 feet, is a conspicuous topographic feature in southwestern Campbell County.

The general physiographic setting of the Eastern Powder River Basin of Wyoming is shown in Figure R2-6.

GEOLOGY

Stratigraphy

The Eastern Powder River Basin contains a rock sequence ranging in age from Precambrian to Recent.

A brief lithologic description of the formations exposed in the region as well as those present in the subsurface is given on Figure R2-7.

Coal-Bearing Formations

The Fort Union and Wasatch formations contain the only commercial coal beds in the region, although the lower half of the Lance Formation contains some thin coal beds.

The Fort Union Formation is made up of three members: the Tullock (lowest), the Lebo (middle), and the Tongue River (uppermost). This distinct threefold subdivision can be mapped with certainty only in the northern part of Campbell County (Map 9, Appendix A). The Tongue River Member is not recognized in the southern part of the region. The top of the Wyodak coal bed marks the top of the formation along much of its eastern

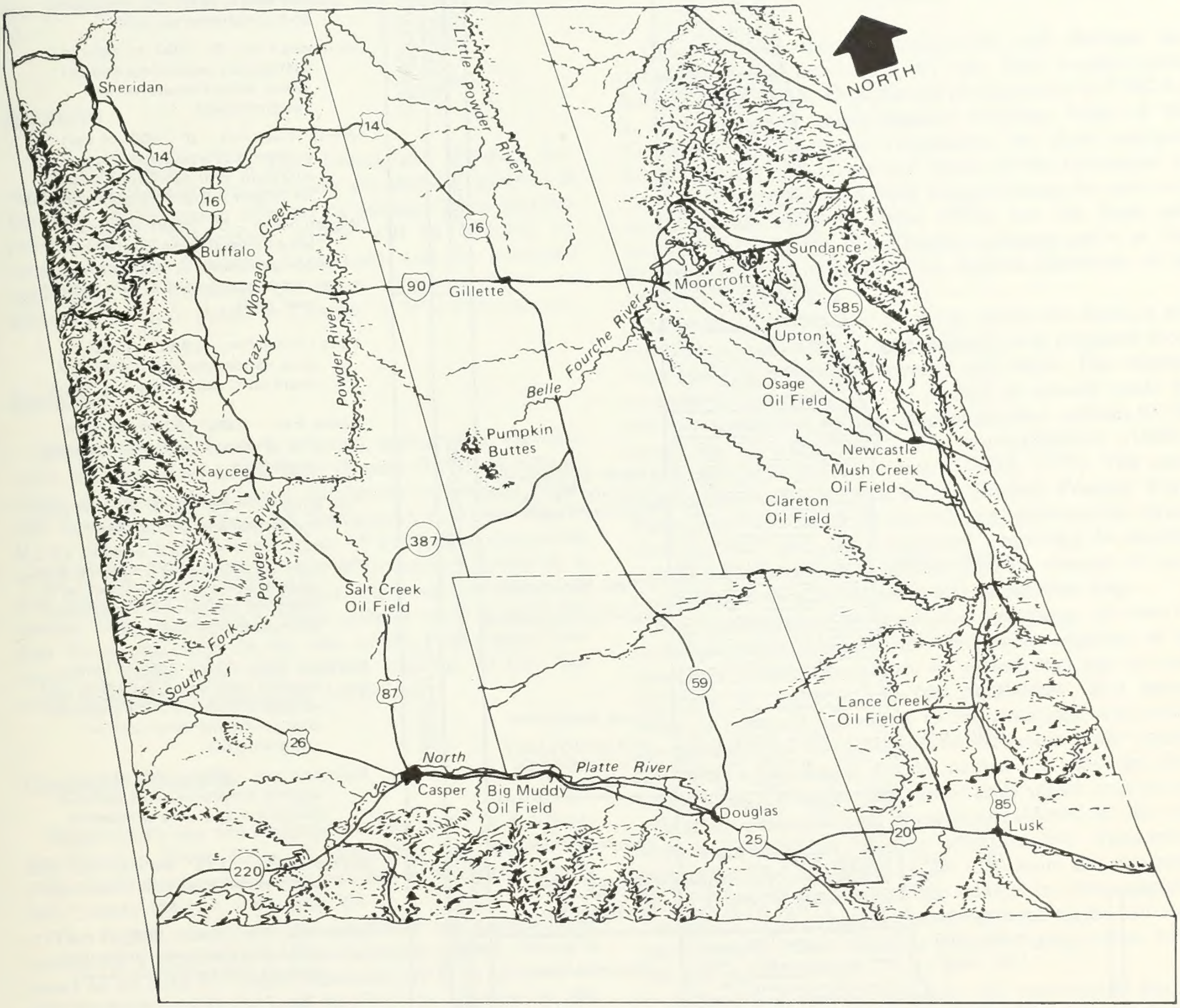


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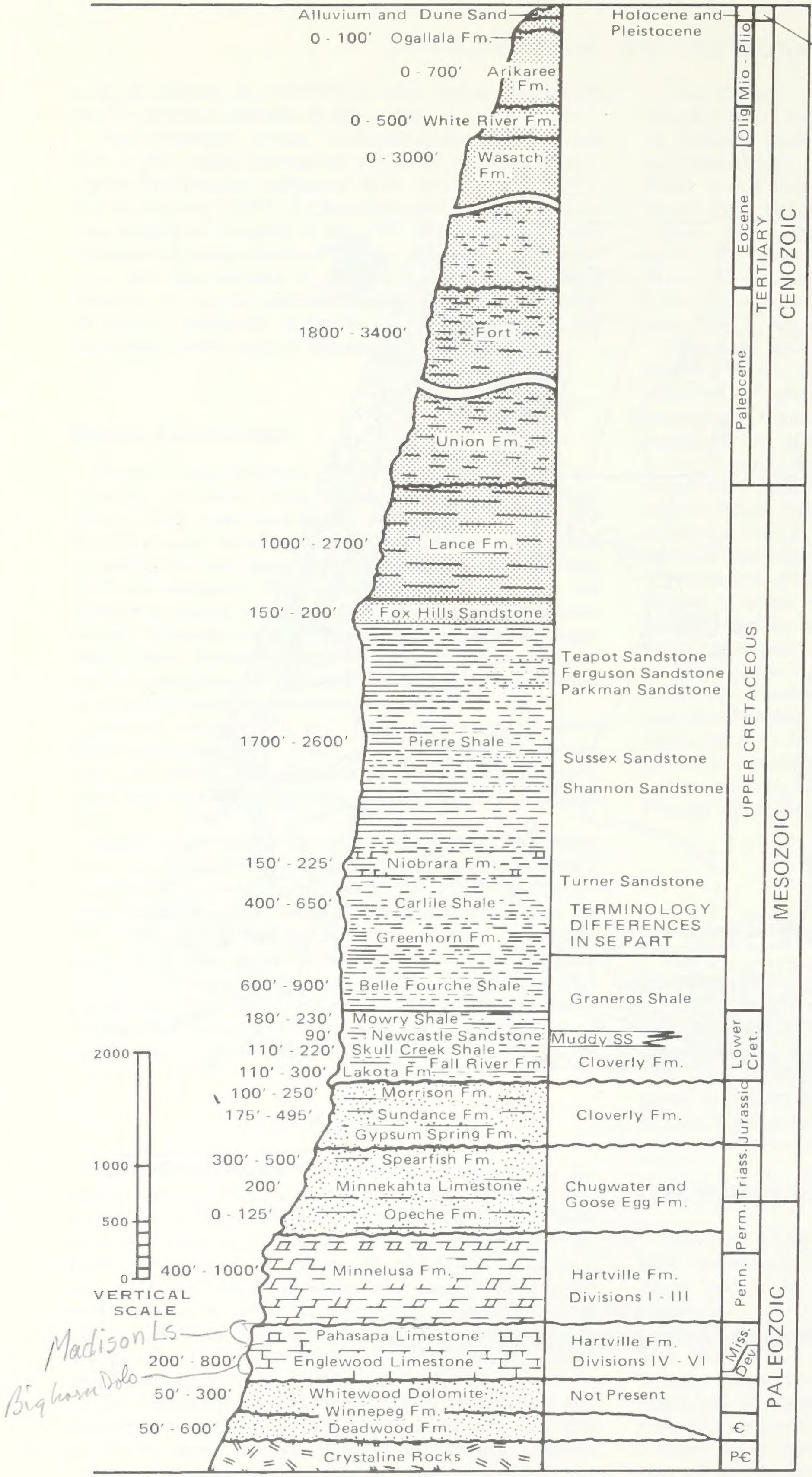
Figure R2-6
PHYSIOGRAPHY OF THE POWDER RIVER BASIN



Holocene and Pleistocene - Unconsolidated clay, silt, and, and gravel

Ogallala Fm. - 0' - 100' of calcareous claystone, siltstone, sandstone and conglomerate beds

Arikaree Fm. - 0' - 700' of light gray tuffaceous sandstone and siltstone, with limestone and conglomerate

White River Fm. - 0' - 500' of varicolored tuffaceous claystone, siltstone, and sandstone with lenticular conglomerate near base

Wasatch Fm. - 0' - 3000' of buff arkosic sandstone, lenticular conglomerate drab siltstone, carbonaceous shale, and many coal beds

Fort Union Fm. - 1800' - 3400' of drab sandstone, siltstone, and shale with numerous coal beds

Lance Fm. - 1000' - 2700' of dark gray shale and yellowish-brown sandstone

Fox Hills Ss - 150' - 200' of light gray sandstone and sandy shale

Pierre Sh. - 1700' - 2600' of dark gray marine shale and claystone with siltstone, sandstone, limestone, and bentonite beds

Cloverly Fm. - 110' - 300' of interbedded light gray sandstone and variegated bentonitic claystone with lenticular chert pebble conglomerate

Morrison Fm. - 100' - 250' of variegated claystone with nodular limestone and silty sandstone lenses

Sundance Fm. - 175' - 495' of red, gray and greenish-gray snadstone and shale

Chugwater Fm. - 300' - 500' of red siltstone and shale with anhydrite, gypsum and sandstone seams

Goose Egg Fm. - 200' of red shale and siltstone containing gypsum, anhydrite, and several gray limestone beds

Division I - 175' of bluish-gray limestone with red, gray, and purple siltstone and dolomitic siltstone

Division II - 225' of light-colored, chalky dolomite and bluish-gray limestone

Division III - 250' of sandstone, shale, dolomite, and breccia beds

(See also Map 9, Appendix A)

Figure R2-7

COLUMNAR SECTION OF ROCK SEQUENCE IN THE EASTERN POWDER RIVER BASIN AND DESCRIPTION OF EXPOSED FORMATIONS

outcrop in the region. Numerous other coal seams are present both above and below the Wyodak (Figure R2-8).

The thickest coal in the Wasatch Formation is the Felix seam about 200 feet above the base. Thinner seams are present both above and below the Felix (Figure R2-8).

Aquifers

The Fox Hills, Lance, Fort Union, and Wasatch formations and Quaternary alluvium are shallow aquifers in that part of the region affected by mining. Deep aquifers present in the subsurface which will be affected by mining are the Madison Limestone and its eastward equivalent, the Pahasapa Limestone. These aquifers are discussed in more detail in Chapter 2, Water Resources.

Structure

Structurally, the basin is a broad, asymmetric syncline with the steep limb to the west (Figure R2-9). Structural relief on top of the Dakota Sandstone (a horizon about 250 feet above the base of Cretaceous rocks in Figure R2-9) ranges from a high point of 5,000 feet above sea level in the southwestern part of Johnson County to a low point more than 10,000 feet below sea level in west central Converse County. Total relief is more than 15,000 feet. Structural relief on the base of the Fort Union Formation is about 6,000 feet, and on the base of the Wasatch Formation is only about 3,000 feet.

Geologic Hazards

Major faults are not known to offset rocks in the Eastern Powder River Basin of Wyoming, but faults with only small displacements are present in northern Campbell County (Map 9, Appendix A).

The region is aseismic (no tendency for earthquakes) except for a small area in the southwest corner, which is rated as an area of "lesser seismicity"(VII or greater on the modified Mercalli scale, or 5.0 or greater on the Richter scale with a frequency of one or fewer earthquakes per decade) (Simon 1972). Two earthquakes are recorded in this area of "lesser seismicity"in the general vicinity of Casper, Wyoming, one in 1894, and one in 1897 (ibid.).

At present coal mine reclamation has resulted in reduced ground stability to depths of about 60 to more than 400 feet over an area of 1,301 acres in the region.

Paleontology

To date, only a limited number of paleontological surveys have been conducted in the region, with most attention being given to fossil vertebrates. A general summary of the fossil-bearing formations, ages, number of known fossil localities, and general fossil types in the region is presented in Table R2-6.

SOILS

Detailed-reconnaissance progressive soil surveys are currently being conducted by the Soil Conservation Service (SCS), U.S. Department of Agriculture (USDA), in both Campbell and Converse counties. Most of the Thunder Basin National Grasslands has been mapped using the new soil taxonomy. Most of the remainder of the two counties has not been mapped using the new soil taxonomy at this date (June 1978), but has been soil mapped using older classification systems such as the USDA 1938 Soil Classification System (Baldwin et al. 1938).

In order to express soil location within the basin, a soil association map (Map 4, Appendix A) was prepared from existing SCS generalized county soil maps. The original maps were prepared over a period of several years by different personnel using soil classification systems of the great soil groups (ibid.), 7th approximation (USDA 1960), and new soil taxonomy (USDA 1975). The compiled soil association map of the Eastern Powder River Basin was correlated using existing information dating back to 1953 and yet interpreted according to modern classification concepts. This identifies an element of questionable accuracy in the basic soil association map.

Soil associations are basically groupings of two or more distinctive kinds of soil that occur together in the landscape in some regularity of pattern but may be very different in characteristics or capabilities. Soil associations are named according to the dominant soils within the associations. For example, an association may contain ten known soil series, but be named for only the three major soils. Consequently, minor soils which may be significant to management are not considered in the map unit description or in the interpretative evaluations. (Quantitative evaluations of the map units are impossible since major series may differ widely in characteristics. Individual evaluations of the component major soil series have limited value since the percent composition within the unit is unknown.)

Appendix B, Soils, includes: soil association descriptions; a table of soil interpretations for regional soil associations which provides the physical, chemical, and management interpretations for the soil series included in each soil association (Table RB-1); and tables of soil series descriptions which provide estimated physical, chemical, and behavior characteristics. Map 4, Appendix A shows soil associations of the Eastern Powder River Basin.

The suitability of the major regional soil series for mined land reclamation material is one of the interpretations on Table RB-1. Until the progressive soil surveys of Campbell and Converse counties (currently being conducted by the SCS) are closer to completion, it will not be possible to state a regional acreage figure for the major soil series present. However, based on experience

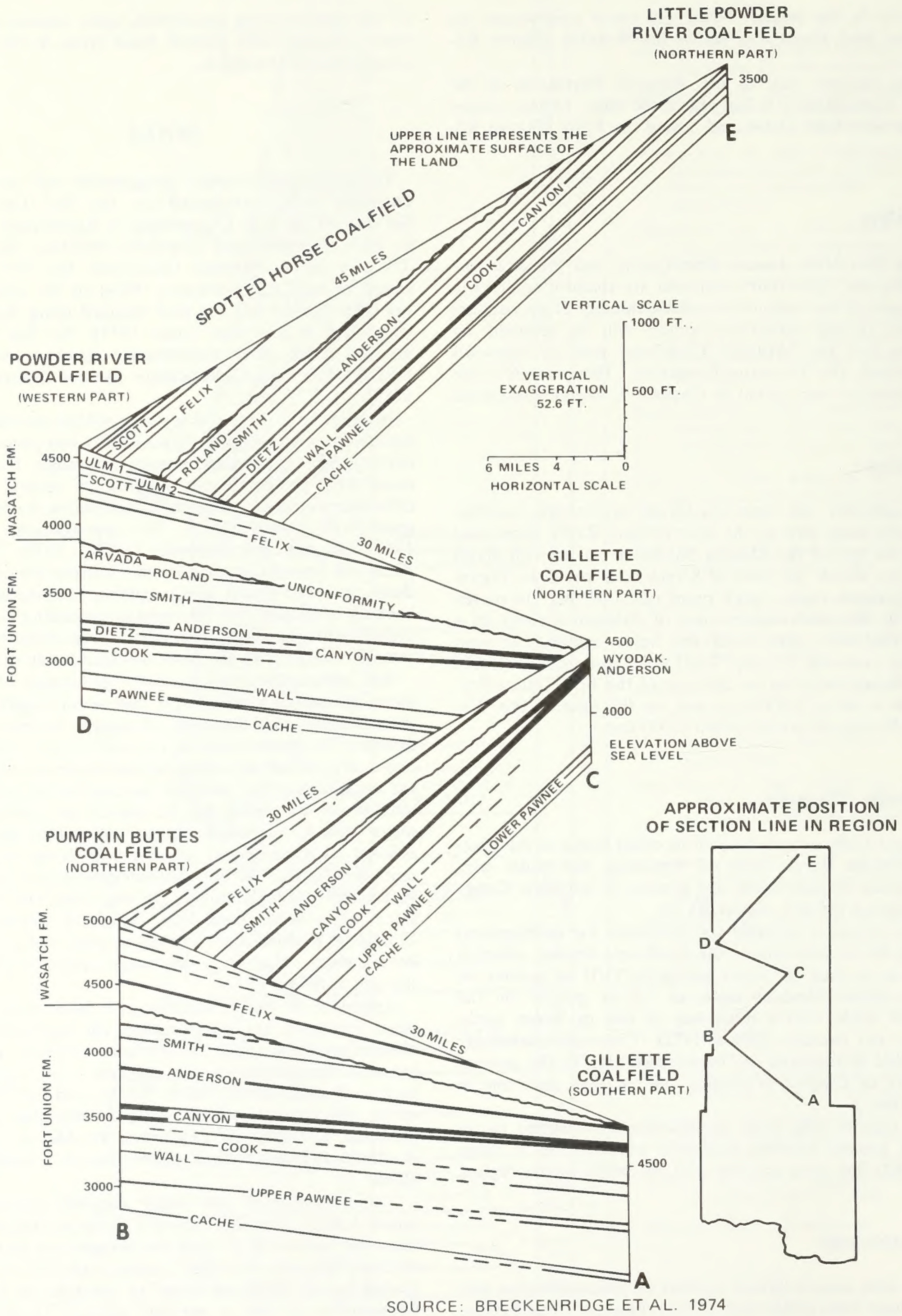


Figure R2-8

CORRELATION AND THICKNESS OF MAJOR COAL SEAMS

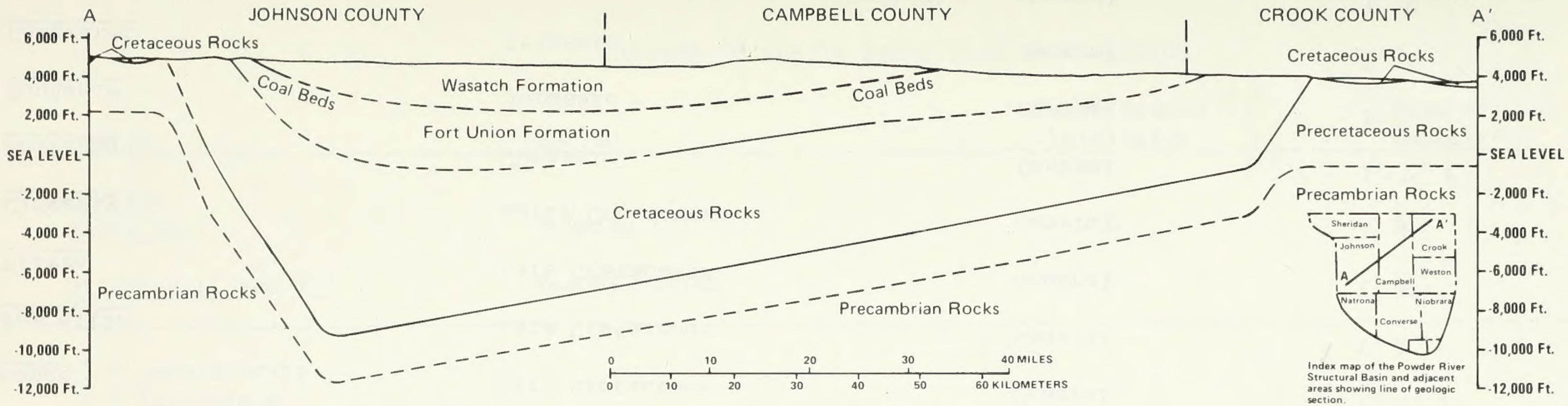


Figure R2-9

GENERALIZED GEOLOGIC SECTION OF THE POWDER RIVER BASIN AND ADJACENT AREAS, NORTHEASTERN WYOMING

TABLE R2-6

SUMMARY OF FOSSIL LOCALITIES IN EASTERN POWDER RIVER BASIN

Formation	Period	Known Fossil Localities	Type of Fossils*
Surficial Deposits	Quaternary	General**	I
		1	V (mammal)
	Tertiary		
Ogallala	Miocene and Pliocene	0	
Arikaree	Miocene	General	I, V, P
White River	Oligocene	1	V (mammal)
		General	I, V, P
Wasatch	Eocene	3	V (mammal)
		1	V (fish)
		General	I, P
Fort Union	Paleocene	4	P (pollen)
		11	P (leaves)
		General	I, V (lower vertebrates)
		0	V (mammals)
Lance	Late Cretaceous	General	I, V, P
Fox Hills	Late Cretaceous	General	I, P
Pierre	Late Cretaceous	General	I, V
Cloverly	Early Cretaceous	General	I, P
Morrison	Jurassic	General	I, V, P
Sundance	Jurassic	General	I
Chugwater	Triassic	General	I, V
Goose Egg	Permian and Triassic	General	I, V

TABLE R2-6
(cont'd)

SUMMARY OF FOSSIL LOCALITIES IN ES REGION

Formation	Period	Known Fossil Localities	Type of Fossils*
Hartville			
Division I	Permian (?)	G	I
Division II and III	Pennsylvanian	G	I

* I = Invertebrate
V = Vertebrate
P = Paleobotanical

** Formation contains fossils throughout, no specific localities identified.

up until this time, we can reasonably expect a greater acreage of the less suitable soils for reclamation purposes to be present in the region than of the most suitable soils.

Soil Formation

Soils of the region have developed mostly with short-grass vegetative cover common to the semiarid Great Plains. Due to prevailing climate and vegetative conditions, organic matter is accumulated slowly, and soils have developed with light-colored surfaces. Subsoil colors are normally light brown or reddish brown, and are often influenced by white, powdery, lime-carbonate accumulations caused by low rainfall and insufficient leaching. Soils of the region are mostly residual (developed in place), and formed from weathered sedimentary bedrock, mostly sandstone and shale.

On gently rolling uplands, bedrock is usually not more than 36 inches below the surface; on more rolling lands the depth to bedrock is about 20 to 30 inches; and on steep slopes, only a few inches of soil or soil material overlie the partly weathered bedrock. Rock outcrops are common on the steepest slopes.

To a marked degree, developed soils reflect the character of the bedrock. Areas of sandy and medium-textured friable (crumbling naturally) soils are underlain by sandstone and sandy shale, and heavy clay soils are underlain by clayey shale.

The sandy loam and loam soils absorb moisture readily. They are thicker than the heavy, or fine-textured soils. Surface layers are well supplied with organic matter and are neutral or only slightly alkaline. Subsoils are friable or only moderately compact. Lower subsoils are calcareous and are represented by a lime-carbonate accumulation zone at depths of 16 to 30 inches.

The gray, heavy clay shale weathers slowly, and the soils developed from it are shallow. These shallow soils have a medium to fine-textured surface and a dense or compact subsoil. They absorb moisture slowly, and runoff is rapid on sloping areas. On steep slopes, little or no soil development has taken place due to geological erosion. Level areas within the gently undulating or rolling uplands are characterized by a microrelief of small hummocks and depressions with salty spots. These soils are mostly neutral to slightly alkaline. The zone of lime-carbonate accumulation may be weakly developed or absent.

Scoria (clinker) gives rise to brown or reddish brown, medium-textured, shallow, gravelly, and rocky soils.

Miscellaneous areas include rough, broken land, rock-land, gullied land, and shale/rock outcrops occupying lands of steep relief. A complex residual soil pattern occurs between the outcrops and ridges. These soils are not classified.

Alluvial soils are developed from a variety of material washed from the uplands and high landscapes and deposited along stream courses. They occupy comparatively narrow, elongated, continuous or broken strips along most of the main drainages. The soils have a grayish brown to dark grayish brown friable surface that contains a fair amount of organic matter, and they are calcareous at or near the surface. Soluble salts in varying quantities are present in some of these soils.

Management problems associated with soils of the Eastern Powder River Basin are strongly related to the climatic and geological setting. Vegetation is sparse due to the short growing season and low precipitation; the productive capacity ranges from 200 pounds per acre on rough, broken lands to 3,000 pounds per acre on bottom-land. The wind and water erosion hazard increases from medium to very high if vegetation is removed and top-soil disturbed. Runoff water is generated from slopes having poor vegetative cover since physical properties of the soil do not allow adequate infiltration or moisture storage. The moisture is lost in runoff that carries along sediment and soluble salts to be deposited in low areas, along streams, or to remain suspended in water systems, thereby lowering the quality of this water.

In addition, soils of the region are easily compacted and highly susceptible to shrinking when dry or swelling when wet. These factors, coupled with low infiltration and permeability rates, increase the hazard for erosion, reduce revegetation success, increase water runoff and flooding, and limit the soils' suitability for reservoirs and as a source of topsoil or construction material.

The most common natural soil problems of the area are (1) clayey textures (having high shrink-swell potentials, low infiltration rates, slow permeability, and poor plant-soil moisture relationships); (2) high wind and water erosion hazards (due to poor ground cover interrelated to slope, soil texture, sedimentary parent materials, short growing seasons, and low available soil moisture); and (3) high levels of soluble salts detrimental to plant growth (concentrated due to ponded water from runoff, high evapotranspiration rates, poor leaching related to slow permeability, and exposed saline and alkaline shales).

Land capability is defined as the suitability of land for use without permanent damage. Land capability, as ordinarily used in the United States, is an expression of the effect of physical land conditions, including climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife.

Land capability classification refers to groupings of soils into special units according to their capability for intensive use, and the treatments required for sustained use. Land capability classification involves consideration of (1) the risks of land damage from erosion and other causes, and (2) the difficulties in land use owing to physical land characteristics, including climate. This classification system has been prepared by the Soil Conservation Service (1973). The SCS recognizes eight classes of land according to the risk of land damage or the difficulty of land use; they are:

Class I. Soils that have few limitations restricting their use.

Class II. Soils that have some limitations reducing the choice of plants or require moderate conservation practices.

Class III. Soils that have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both. Generally the last soil grouping considered suitable for cultivated crops; requires major treatment.

Class V. Soils that have little or no erosion hazard but that have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI. Soils that have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII. Soils that have very severe limitations that make them unsuitable to cultivation, and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or aesthetic purposes. Generally, Class VIII soils do not respond to management treatment within agricultural purposes.

Land capability classification has been in use by the SCS for a number of years in assisting landowners with their farm and ranch planning. Soil surveys are interpreted into capability groups and range sites (a range site is a distinctive kind of rangeland that differs from other kinds of rangeland in its potential to produce native plants) according to production potentials and conservation treatment needs. The SCS maintains yield records on the performance of these groupings according to soil type within each land resource area.

The land capability and range site classification systems are nationally accepted methods for determining agricultural land potential. The systems provide established techniques for the description of existing land use potentials prior to major disturbance, such as mining.

The "Potential Soil Capability Classification for Reclamation"has been described by Hayden D. Rounsaville (1976) as a means to link the existing land capability classification methods to predicted potentials and performance of reclaimed lands. Rounsaville's model is based on the assumption that the restored landforms and recreated soils perform like soils which occur naturally in the existing environment. This assumption has not been proved or disproved on mined land as yet due to the short time period that these systems have been applied to mined lands.

The process requires an assessment of the existing natural soils to determine how many acre-feet of suitable material are available for reclamation use. The assessment includes both physical and chemical properties. Predicted classes (according to capability classes and range sites) are based on the characteristics of the replaceable "topsoil,"the depth, and the slopes of the planned reformed land. Once these predicted classes have been established, the potential production performance can be derived from the normal SCS sources.

This evaluation technique will not only describe existing potentials, but also provides quality standards for reclamation and a method to evaluate reclamation alternatives, indicating what uses are possible in reclamation, expected yields for cost-benefit evaluations, and management requirements for long-term sustained use.

The reclamation potentials displayed within the site-specific portion of this document were derived from the model described here.

WATER RESOURCES

Groundwater

The aquifers (water-bearing formations) described in this statement have been divided into three units. The lithology of formations comprising each unit is similar and, therefore, the water-bearing properties of the formations are similar. From oldest to youngest of these units are: (1) Bighorn Dolomite and Madison Limestone, (2) Fox Hills Sandstone and the Lance, Fort Union, and Wasatch formations, and (3) alluvium. The Bighorn Dolomite is equivalent to the Engelwood Dolomite, and the Madison Limestone is equivalent to the Pahasapa Limestone. The stratigraphic positions of these formations and brief lithologic descriptions are shown on Figure R2-7.

Bighorn Dolomite and Madison Limestone

The permeability of the Bighorn Dolomite and the Madison Limestone is the result of fracturing and solution that occurred after the formations were consolidated. This type of permeability differs greatly from place to place but yields of more than 1,000 gallons per minute (gpm) are available where cavernous (containing caves) and fractured zones are present. Of three wells tapping the Madison in the Midwest oil field at a depth of about 5,000 feet, one had an initial flow of 3,900 gpm with 150 pounds per square inch (psi) flowing pressure at the surface, a second well yielded 7,000 gpm with 179 psi flowing pressure at the surface, and the third yielded 4,750 gpm with unknown flowing pressure. Several wells in the Newcastle, Wyoming area have flows of more than 1,000 gpm from the Pahasapa at depths of about 3,000 feet. A well near Osage, Wyoming had an initial flow of about 800 gpm from the Pahasapa. A well about 30 miles north of Lusk, Wyoming, which did not penetrate cavernous or highly fractured material, yielded only 150 gpm with 330 feet of drawdown (Anderson and Kelly 1976). This yield was obtained only after the well was treated with acid to increase the yield. Konikow (1975) did a regional analysis of the Madison Limestone in the Powder River Basin. He concluded the regional transmissivity probably lies between 0.010 and 0.025 square feet per day (ft^2/day) and the storage coefficient probably ranges between 0.00001 and 0.00025. See Appendix B, Groundwater, for an estimation of well yield based on transmissivity.

Recharge to the Madison occurs on its outcrop from precipitation and runoff. The formation is exposed in the Big Horn Mountains, at the north end of the Laramie Range, and in the Black Hills. Some recharge is also believed to occur in the Hartville Uplift area where the Madison is exposed and where, because of the removal of overlying rocks by erosion, the Madison is overlain by water-bearing sand of Tertiary age. Recharge to the Madison Limestone in northeastern Wyoming was estimated to be 75,250 acre-feet per year (Wyoming State Engineer 1976).

Swenson and others (1976) state the configuration of the water level surface in the center of the Powder River Basin, an area which includes Campbell and northern Converse counties, is conjectural; however, they go on to state, "The relatively flat gradient implied in the central part of the basin could indicate either the quantity of underflow is small or the transmissivity is high"

There is one analysis of water from a well in the Madison in the region available. The well is in west central Converse County, Section 7, T. 34 N., R. 76 W., 6th P.M. The water from this well is a sodium-chloride type with a total dissolved solids content of 3,726 milligrams per liter (mg/l) (Hodson 1974).

The only use of water from the Madison Limestone in the area in 1977 was by the town of Douglas. The water is obtained from a spring southwest of Douglas and about 6 miles south of the region. Gillette has recently completed drilling a Madison well east of the region, but the well had not been tested as of August 1977.

Fox Hills Sandstone and the Lance, Fort Union, and Wasatch Formations

Most water wells in the Fox Hills Sandstone and the Lance, Fort Union, and Wasatch formations are either shallow stock or domestic wells or comparatively deep industrial wells. The stock and domestic wells are generally drilled only deep enough to obtain an adequate supply of water that is suitable in quality for the intended use. Therefore the formation developed depends on the well location, because the formations in general have a westward dip, and the highest altitudes are on the west side of the region. These stock and domestic wells are usually less than 1,000 feet deep and have yields in the order of 25 gpm. Industrial supply wells, most of which were drilled for water for secondary recovery of oil, are usually deeper than 1,000 feet; for some uses, the Office of the Wyoming State Engineer has, in the past, specified the water shall be from the deeper horizons to protect shallow supplies. These wells are often in the order of 3,000 to 5,000 feet deep and are open to two and sometimes three formations. No wells, however, are completed throughout single formations; thus differences in water-bearing properties between formations, and areal changes in water-bearing properties of a formation, are not known. All the available data from aquifer tests for these formations and the alluvium in the Eastern Powder River Basin are given in Appendix B.

Recharge to, and discharge from, the Fox Hills, Lance, Fort Union, and Wasatch is complex because the sandstone and coal aquifers in the unit are separated by shale of significantly lower permeability which impedes the vertical flow of water. The result is that there are large differences in the static head of water at different depths, and the movement of water is controlled by these differences. Because of the large number of aquifers that occur and the variation in topography, a large number of conditions are possible. Figure R2-10 shows two different hydrologic conditions that could occur with the same geologic and topographic conditions. The only difference between A and B is that the potentiometric surface in aquifer 2 indicates a recharge area in A and discharge area in B. A well drilled into aquifer 2 would have artesian flow in the one example but not in the other.

Recharge, if known, cannot be used without other information to determine the quantity of water that can be developed. Under natural conditions, recharge and discharge are in balance. New discharge points, such as wells, may for a time obtain all their water from storage in the aquifer; however, if discharge continues over an extended period, natural recharge will have to increase or natural discharge will decrease.

Where there are large differences in the static head at different depths such as shown in Figure R2-10, a potentiometric surface is meaningful only if it describes the static head along a specified surface or stratum. This data is available for the Wyodak coal in the area near the outcrop through the work done by the mining companies, and this data is summarized in Figure R4-11. Figure R2-11 shows the direction of movement of water at depth in the northern part of the area. Most of the water wells used for control points in drawing the figure are open to the Fox Hills Sandstone and several hundred feet of overlying sandstone. Therefore, the static head of water in the wells represents a composite of levels through a large, although not necessarily the same, interval.

Chemical analyses of 138 water samples from wells tapping the Fox Hills Sandstone and the Lance, Fort Union, and Wasatch formations in the region have been reported by Hodson (1971). The report shows the dissolved solids content of water ranges from 215 mg/l to 8,620 mg/l. Hodson and others (1973) state the dissolved solids content of water from most wells ranges from 500 mg/l to 1,500 mg/l.

The principal cations (positive ions) found in the water are calcium, magnesium, and sodium. The principal anions (negative ions) are sulfate and bicarbonate. Riffenberg (1925) studied the quality of water in the northern Great Plains and found the water from shallow wells in the Lance and Fort Union formations was hard, and the less mineralized water was a calcium, or calcium-magnesium-sulfate type. Above about 700 mg/l, the sulfate and sodium increased in direct proportion to total dissolved solids.

As the shallow water moves through the formation, the chemical type is changed by cation-exchange softening and sulfate reduction. Therefore, the water from the deeper part of the aquifers is soft, and whereas water from some wells contains large amounts of sulfate, other water contains very little, and the dominant chemical

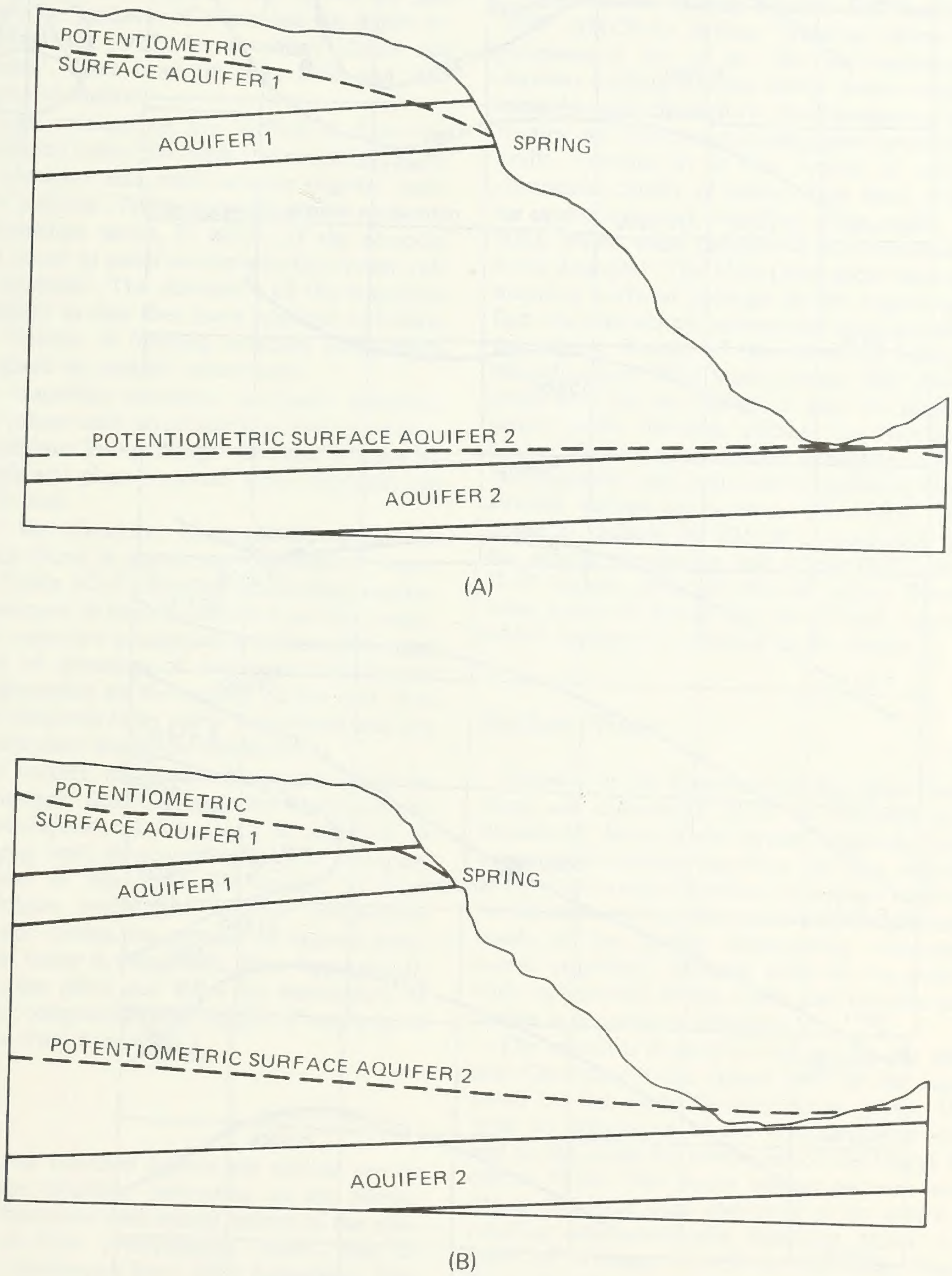


Figure R2-10
EXAMPLES OF HYDROLOGIC CONDITIONS OCCURING IN THE REGION

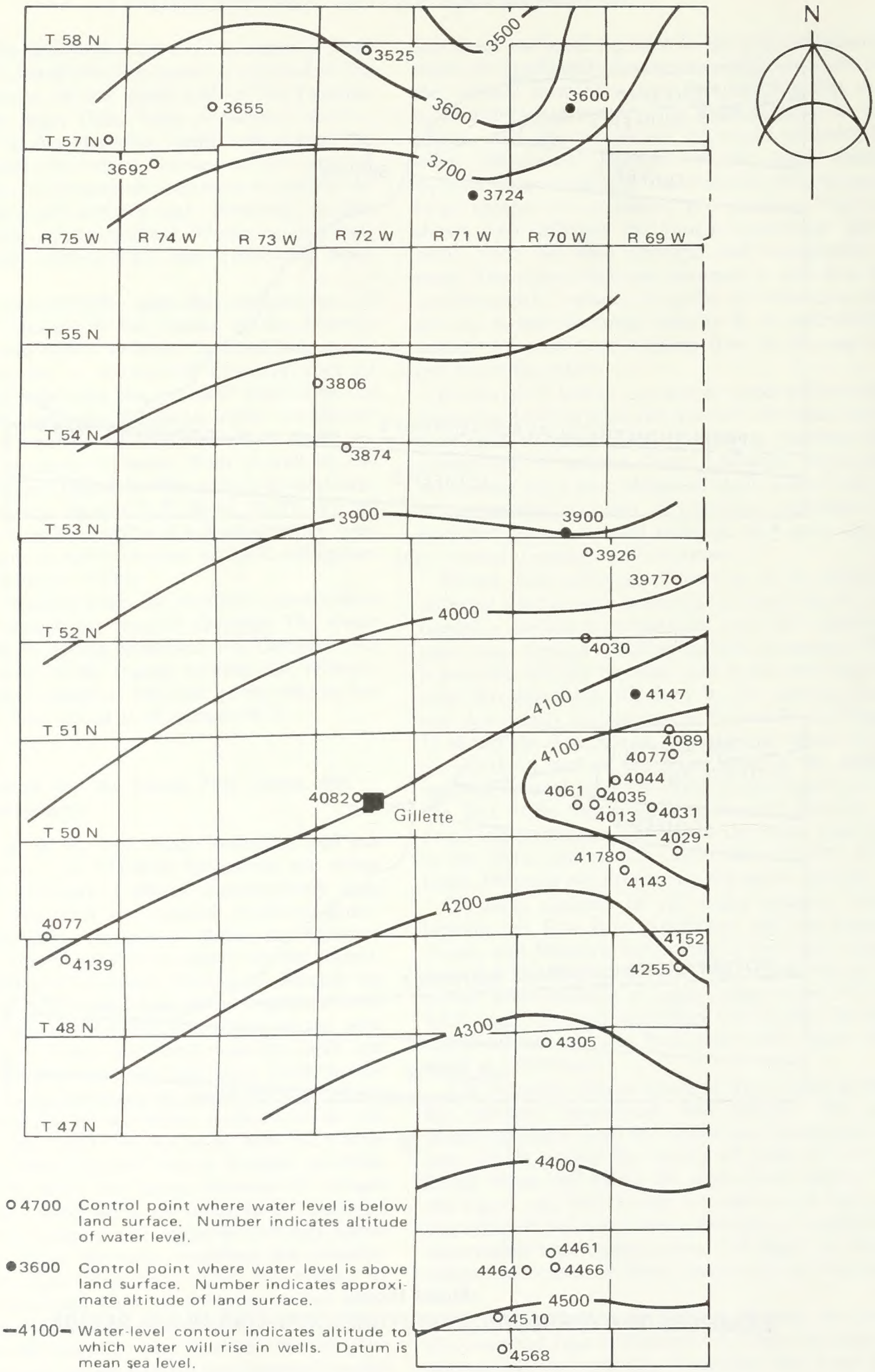


Figure R2-11

GENERALIZED MAP OF WATER LEVELS IN WELLS COMPLETED IN THE FOX HILLS SANDSTONE, LANCE FORMATION, AND LOWER FORT UNION FORMATION IN THE NORTHERN PART OF THE REGION

type is sodium bicarbonate. Figure R2-12 shows the relationship between the hardness of water and the depth described by Riffenberg (1925) for the Fort Union and Lance formations. Water from the Fox Hills and Wasatch in the region is similar.

Weathered coal oxidizes on the surface to form the more soluble mineral leonardite with the potential for release of trace elements and water-soluble organic compounds such as phenols. Trace elements, those elements found in the transition series, D block, of the periodic table, generally occur in small amounts in the system relative to other elements. The chemistry of the transition elements is complex in that they have multiple oxidation states and are capable of forming complex compounds with other inorganic or organic constituents.

Many of the transition elements, in minute amounts, are essential to animal and plant nutrition and are therefore incorporated into living things. As coal is more or less a metamorphosed plant material, trace elements are to be expected in coal.

Even though the transition elements accumulate in coal, they are not found in appreciable amounts in water from coal. (See Table R2-7.) Possible controlling mechanisms for the transport of trace elements from the weathered coal to the water are precipitation of insoluble compounds (because of presence of hydrogen sulfide and high pH), and adsorption on the surface of the coal. It is also possible the elements form stable complexes and are not detected by standard analytical methods.

Organic material leaving the leonardite matrix could be transported unchanged, adsorbed on other coaly material, or undergo subsequent reactions such as oxidation or reduction, changing both its physiological and transport properties. Because of the ability of carbon to form chain, branched-chain, cyclic, and ring-like compounds with substituted side chains, the number of organic compounds possible in water is staggering. (See Appendix B, Groundwater, Tables RB-2 and RB-3 for description of classes of organic compounds and results of analysis of water for organics from four wells.)

Alluvium

Yields up to a few hundred gallons per minute can be developed from the alluvium depending on the permeability, saturated thickness, and lateral extent of the alluvium. Recharge is from precipitation, runoff, and, in some areas, water discharged from older formations. Discharge is by evaporation, transpiration, wells, and in some areas, into older formations or flow into streams. The movement of the water for all practical purposes is in the same direction and at the same gradient as the valley in which it is contained, because the alluvium in the valleys is of such limited thickness and width.

The chemical type of the water from the alluvium is similar to that described for water from shallow wells in the Fox Hills, Lance, Fort Union, and Wasatch formations. The water may be higher in dissolved solids, however, as the result of concentration by evaporation and transpiration.

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) defines "alluvial valley floors"for the purposes of the act as "the unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation and windblown deposits" The U.S. Geological Survey is currently mapping surficial geology in the region and has identified unconsolidated, stream-laid deposits along streams in the region. Results of this work are being published as Miscellaneous Field Studies Maps (MF Map series). The maps may be purchased or may be inspected at some larger public libraries, such as the Natrona County Library. Shallow groundwater occurs in many of the alluvial deposits, and soils and vegetation characteristic of alluvial valleys are present. Therefore, "alluvial valley floors"as defined by SMCRA apparently are present in the region. Hardaway and others (1977) have identified 10.35 square miles of alluvial valley floors within the lease areas of mines that have been approved, or for which approval is pending, in the region.

Surface Water

Streams in the Eastern Powder River Basin of Wyoming are ephemeral (flow in response to rainfall or snowmelt). Most of the stream channels, however, have intermittent reaches that flow for long periods each year at very low rates. This flow is seepage from water stored in the alluvium as the result of precipitation or as the result of the stream intercepting water-bearing rock layers (aquifers). Streams seem to be drier (closer to truly ephemeral) in the south and become progressively wetter in a northern direction.

The region is drained to the east by the Belle Fourche and Cheyenne rivers (about 54% of the region), to the north by the Little Powder River (about 19%), to the west by tributaries of the Powder River (about 16%), and to the south by tributaries of the North Platte River (about 11%). The major stream patterns are dendritic. Mines that have been approved or for which approval is pending will eventually intercept about 1,100 square miles of drainage, mostly in the Belle Fourche River Basin, but the main channels are to be supplemented with by-pass channels so that flow from the drainage will not interrupt mine operations (Figures R2-13 and R2-14).

The mean annual unit streamflow ranges from about 0.008 cubic feet per second per square mile (cfsm) to about 0.011 cfsm from the larger drainages in the region, and from about 0.01 cfsm to about 0.05 cfsm from drainages of about 1 square mile. The seasonal distribution of streamflow reflects the seasonal distribution of snowmelt and rainfall. (See Figures R2-15, R2-16, and R2-17.) The hydrographs for the streams in the northern part of the region show two peak runoff periods, one corresponding

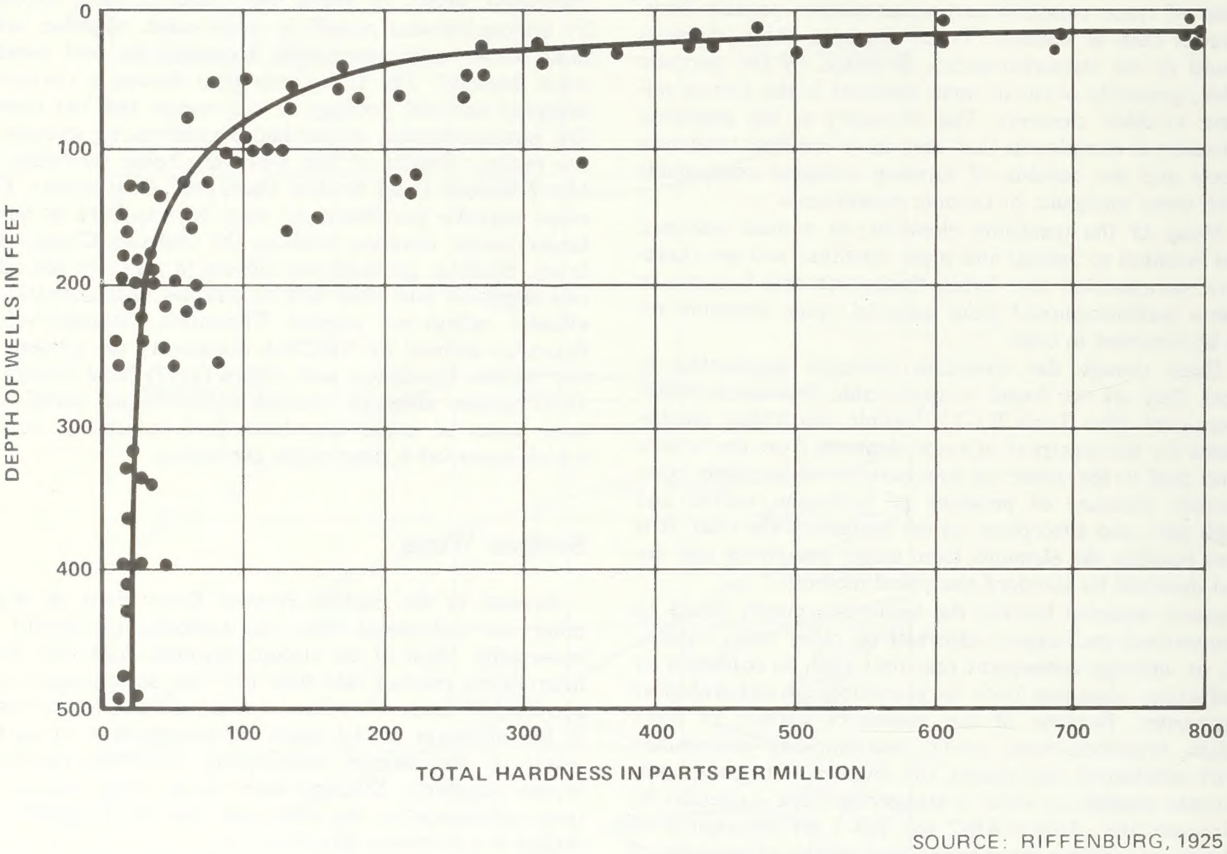


Figure R2-12

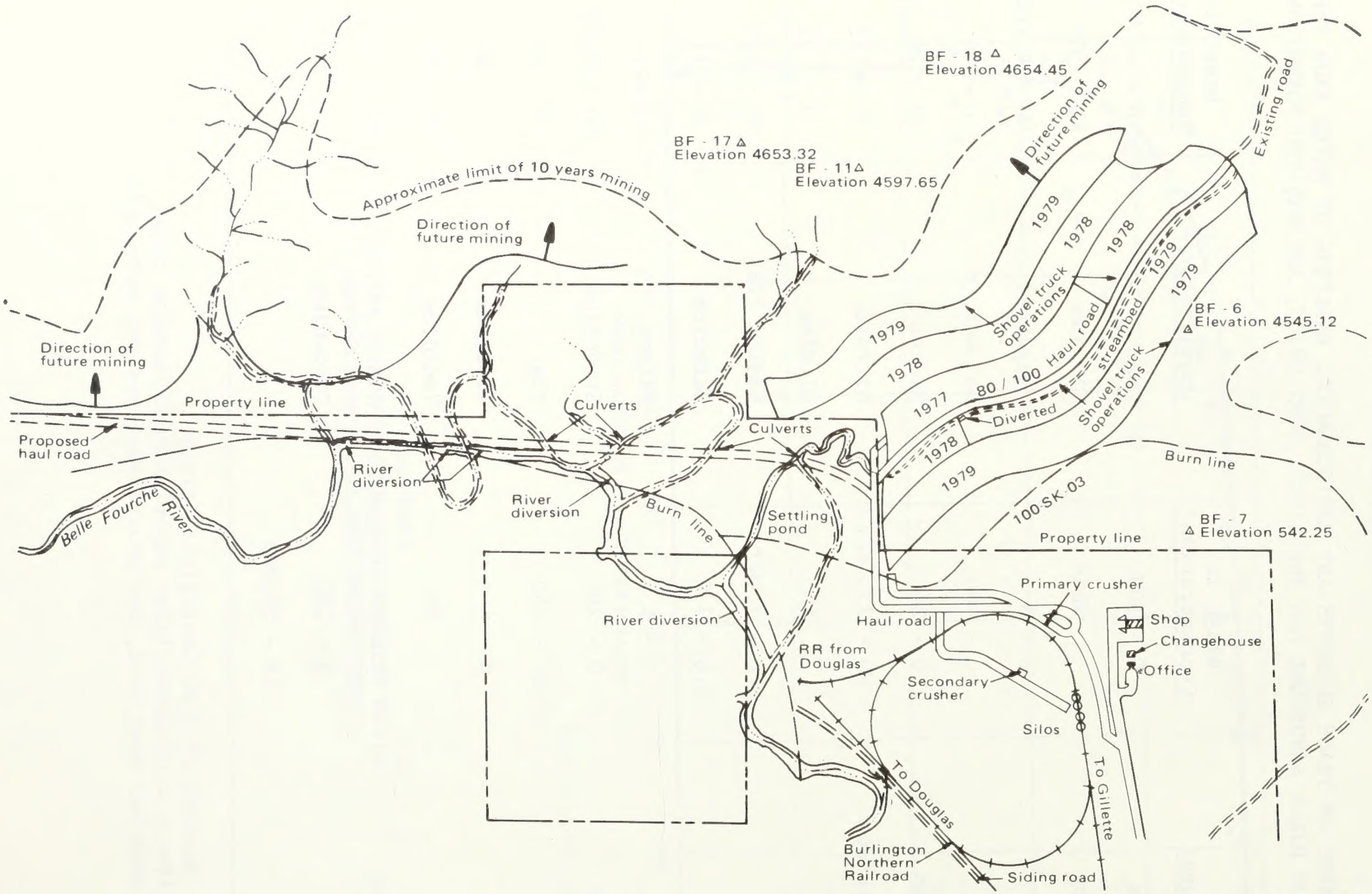
RELATION OF TOTAL HARDNESS TO DEPTH OF WELLS IN FORT UNION AND LANCE FORMATIONS

TABLE R2-7

RANGE OF TRACE ELEMENTS AND RADIOCHEMICAL ANALYSIS OF WATER FROM THE FOX HILLS SANDSTONE AND THE LANCE, FORT UNION, AND WASATCH FORMATIONS

Constituent	Range in Concentration*	Constituent	Range in Concentration*
Aluminum	0 - 100	Lead	0 - 10
Antimony	ND**	Lithium	ND - 390
Arsenic	0 - 8	Manganese	ND - 9,100
Barium	0 - 400	Molybdenum	0 - 44
Beryllium	0 - 30	Nickel	0 - 26
Beta emission	ND - 23 pc/1	Nitrate	0 - .49
Bismuth	ND	Nitrite	0 - .01
Boron	0 - 5,400	Radium 226	ND - 2.2
Bromide	0.0 - 3.8	Selenium	0 - 1
Cadmium	0 - 6	Silver	Trace
Chromium	0 - 20	Strontium	ND - 6,500
Cobalt	3< - <50	Tin	ND
Copper	0 - 4	Titanium	ND
Gallium	ND	Vanadium	0 - 31
Germanium	Trace	Zinc	ND - 430
Iodide	0 - .02	Zirconium	ND
Iron	10 - 37,000		

Source: Records of U.S. Geological Survey
* Results in micrograms/liter except when otherwise noted
** Analysis has been made, but constituent was not detected



SOURCE: SUN OIL COMPANY, 1974

Figure R2-13
TYPICAL MINE PLAN SHOWING RIVER CHANNEL CUTTOFFS

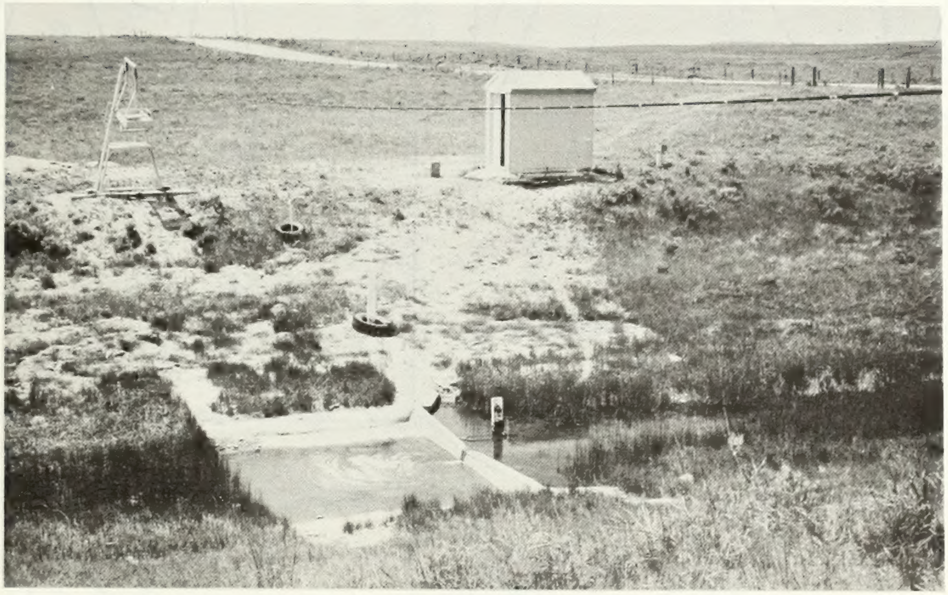
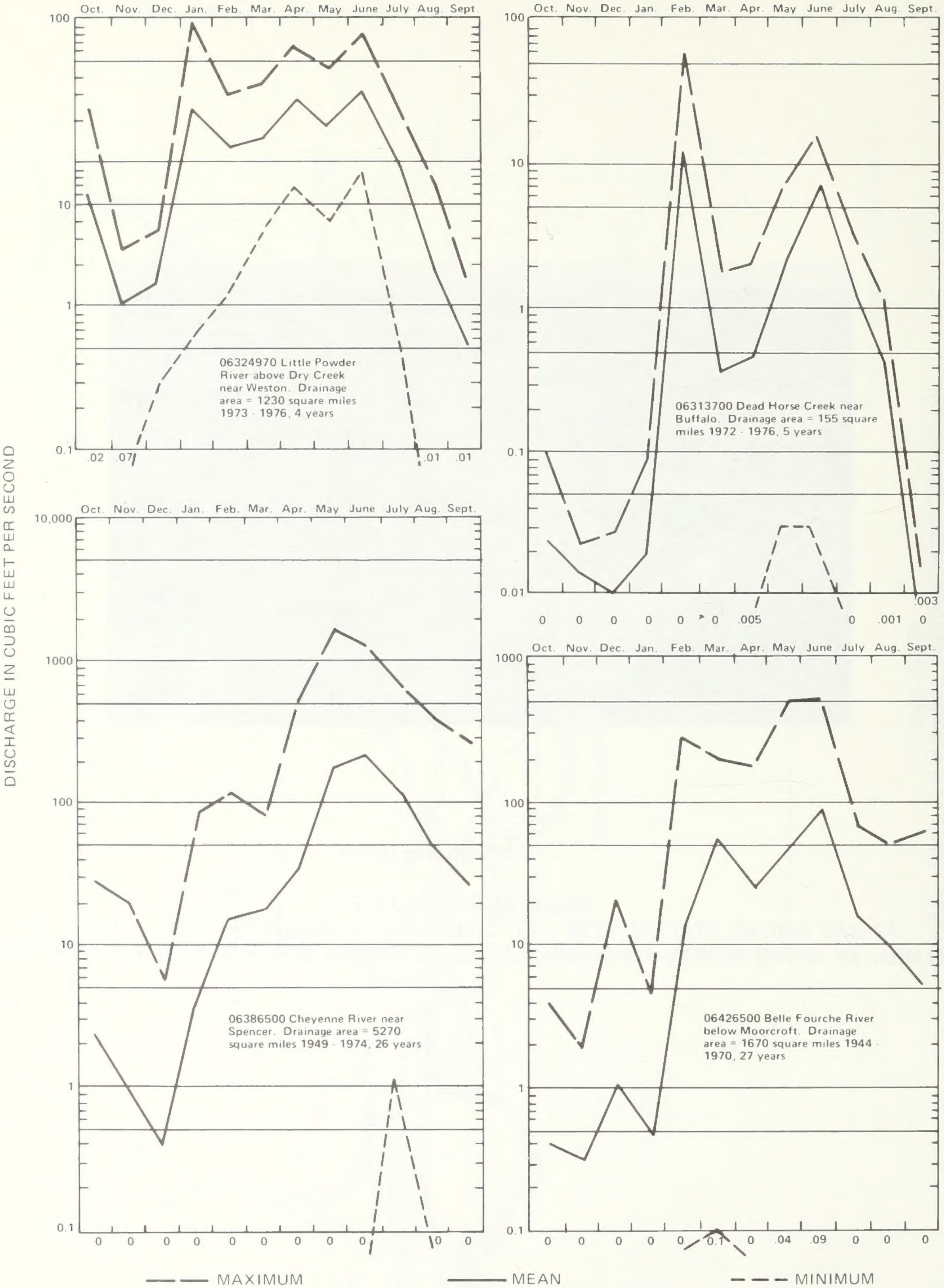


FIGURE R2-14

BELLE ROURCHE RIVER -
STREAM GAGING STATION WITH (1) CABLEWAY FOR MEASURING HIGH FLOWS, AND
(2)SHELTER WHICH HOUSES STAGE-MEASURING, SEDIMENT, AND WATER QUALITY INSTRUMENTS.



COMPILED FROM U.S.G.S. RECORDS

Figure R2-15
MONTHLY HYDROGRAPHS FOR SELECTED STREAMS

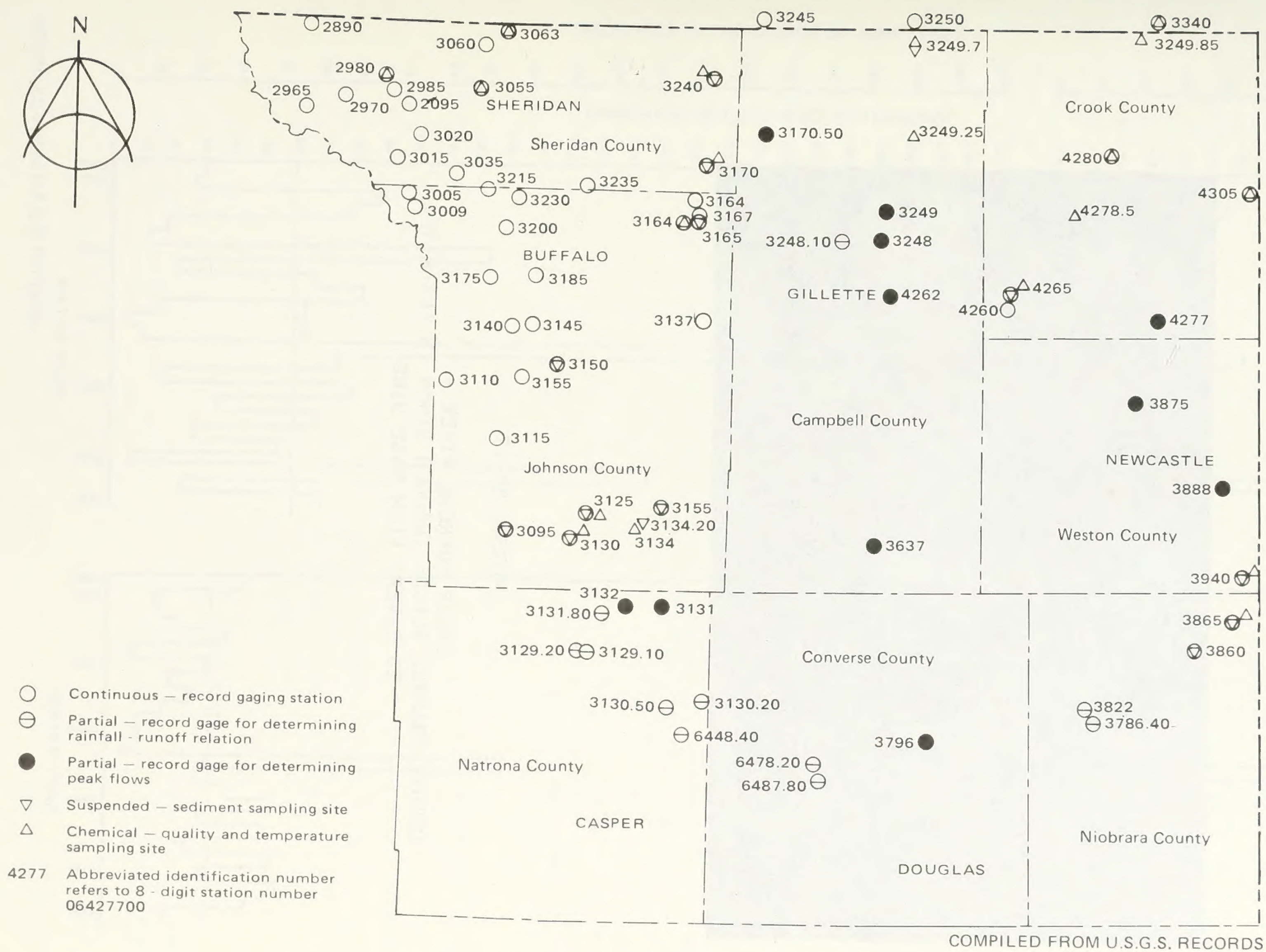


Figure R2-16

LOCATIONS OF SURFACE WATER GAGING STATIONS AND SAMPLING SITES

FIGURE R2-17

BELLE FOURCHE RIVER -
CUTOFF CHANNEL SLICES THROUGH BENDS IN THE RIVER
TO DIVERT FLOW PAST MINE.

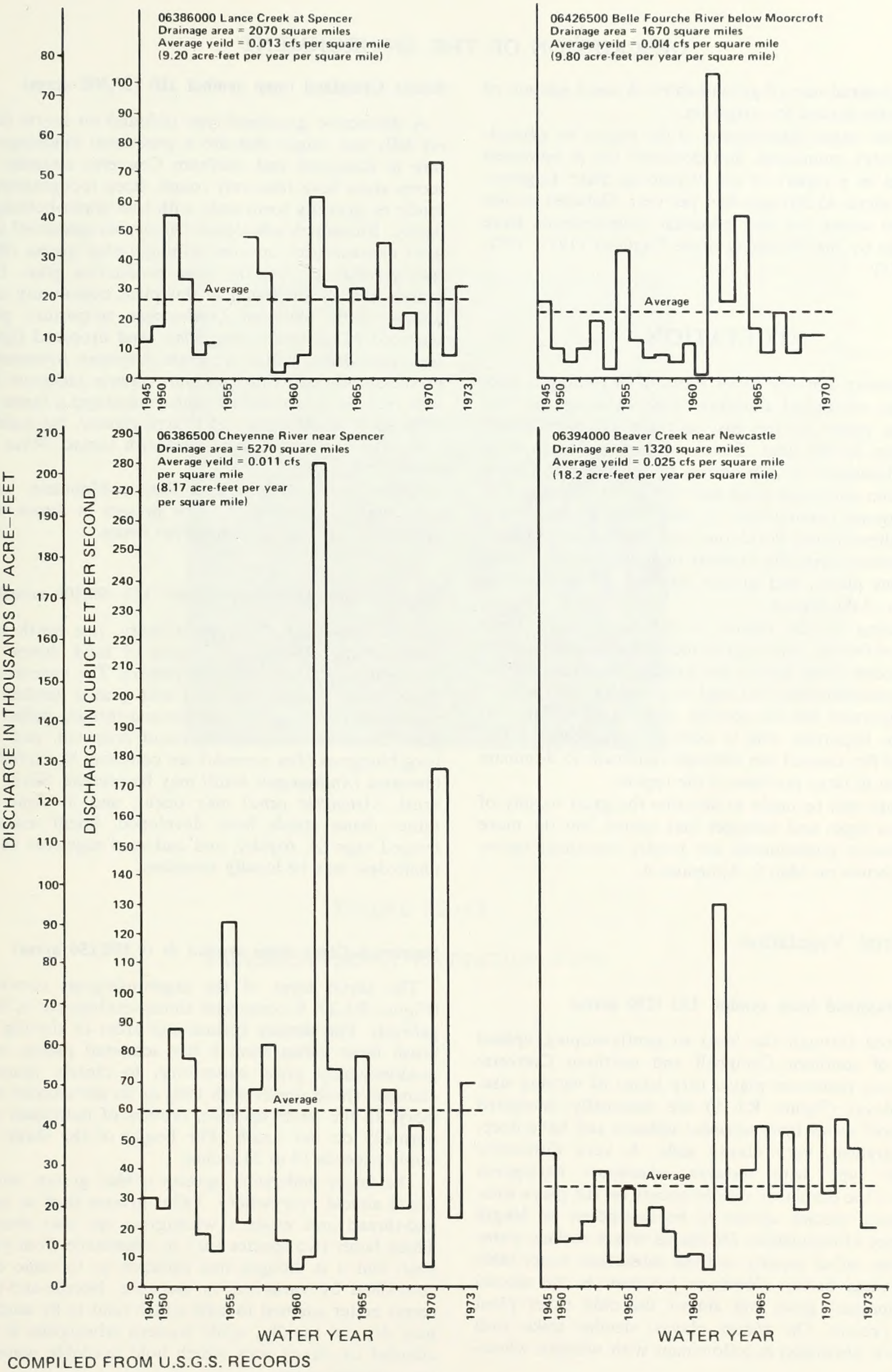


Figure R2-18

YEARLY HYDROGRAPHS OF SELECTED PLAINS STREAMS

largest industrial user of groundwater. A small amount of groundwater is used for irrigation.

The total water consumption in the region by agriculture, industry, municipal, and domestic use is estimated from data in a report of the Wyoming State Engineer (1972) as about 45,000 acre-feet per year. Detailed studies of present water use and potential developments have been made by the Wyoming State Engineer (1971, 1972, 1973, 1974).

VEGETATION

The Eastern Powder River Basin of Wyoming is considered an ecological transition zone between the true shortgrass plains to the east and the northern desert shrub type to the west. Local vegetation communities may be dominated in appearance by big sagebrush, they also contain numerous grass and forb species common to the shortgrass communities of the Great Plains. While both coniferous and deciduous woodland occur locally, the vegetation typically consists of low-growing shrubs, herbaceous plants, and grasses adapted to the semiarid condition of the region.

Vegetation in the region is influenced by a large number of factors. Among the most important determining and controlling factors are grazing, fire, climate (especially precipitation), soil, and topography. Soil is especially important for site-specific plant species. Fire has played an important role in controlling sagebrush. The advent of fire control has allowed sagebrush to dominate vegetation in large portions of the region.

No attempt will be made to describe the great variety of vegetation types and subtypes that occurs, but the more representative communities are briefly described below and are shown on Map 5, Appendix A.

Terrestrial Vegetation

Playa Grassland (map symbol 1A) (250 acres)

Scattered through the level to gently-sloping upland regions of southern Campbell and northern Converse counties are numerous playas (dry lakes) of varying size. These playas (Figure R2-19) are seasonally inundated with runoff water from adjacent uplands and have deep, poorly drained, very clayey soils. A very distinctive grassland type with western *wheatgrass (Agropyron smithii)* as the dominant species occurs on the playa sites. Subordinate species appear to be dependent on length and degree of inundation. On playas where surface water evaporates rather rapidly and the subsurface water table drops, foxtail barley *(Hordeum jubatum)* is the second most important grass and almost the only other plant species present. On wetter playas, slender spike rush *(Eleocharis aricu*laris) is codominant with western wheatgrass.

Scoria Grassland (map symbol 1B) (27,300 acres)

A distinctive grassland type is found on scoria (clinker) hills and ridges that are a prominent landscape feature in Campbell and northern Converse counties. The scoria areas have relatively rough, steep topography, and sandy to gravelly loam soils with low water-holding capacity. Bluebunch *wheatgrass (Agropyron spicatum)* is the most characteristic species, although blue grama *(Bouteloua gracilis)* is often the most productive grass. Other grasses and shrubs found in this plant community are as follows: little bluestem *(Andropogon* scoparius), prairie sandreed *(Calamovilfa longifolia)*, sand dropseed *(Sporoblus cryptandrus)*, Indian ricegrass *(Orysopsis* hymenoides), needle-and-thread *(Stipa comata)*, prairie *junegrass (Koeleria cristata)*, globemallow *(Sphaeralcea* spp.), *lupine (Lupinus* spp.), small soapweed *(Yucca glauca)*, big *sagebrush (Artemisia tridentata)*, and skunkbush sumac *(Rhus trilobata)*.

Other shrubs and stunted Rocky Mountain juniper *(Juniperus* scopulorum) may be present in draws where moisture conditions are somewhat better.

Sandhills Grassland (map symbol 1C) (90,100 acres)

In southwestern Converse County, just north of the North Platte River, is a region of sand dunes. Both active and stablized dunes are present. The vegetation on these dunes is open grassland with prairie sandreed the most conspicuous grass. Needle-and-thread, Indian ricegrass, blue and hairy grama, sand dropseed, and Sandberg bluegrass *(Poa secunda)* are common. Scattered sand bluestem *(Andropogon hallii)* may be present. Silver sagebrush *(Artemisia cana)* may occur, and in some areas rather dense stands have developed. Small soapweed, fringed sage *(A. frigida)*, and cudweed sagewort *(A.* graphaloides) may be locally abundant.

Sagebrush-Grass (map symbol 4) (4,188,150 acres)

The shrub layer of the sagebrush-grass community (Figure R2-20) is composed almost exclusively of big sagebrush. The density (plants/unit area) of the big sagebrush layer varies from a few scattered plants, with a predominantly grass understory, to closely spaced or clumped shrub stands with little or no herbaceous understory. In the latter instance, crowns of individual plants normally do not touch. The height of the shrub layer rarely exceeds 18 to 24 inches.

The major understory species is blue grama, which is found almost everywhere. Taller grasses such as needle-and-thread and western wheatgrass are also abundant. These latter two species vary in abundance from year to year, and it is thought this variation is, to some extent, controlled by variations in moisture. Needle-and-thread seems better adapted to soils which tend to be sandy and may dry out rapidly, while western wheatgrass is better adapted to clayey soils which hold available water into the growing season.

FIGURE R2-19

SAGEBRUSH-GRASS VEGETATION TYPE

FIGURE R2-20

BOZEMAN TRAIL RUTS--CLASS I

to the late winter snowmelt, and one corresponding to the spring rainfall. All streams in the region show the characteristic extreme low-flow period from October through January. (See Table RB-5, Appendix B, Surface Water.)

The extreme variation in streamflow from year to year of prairie streams in semiarid areas is illustrated by the maximum and minimum curves in Figure R2-18.

The surface water flow in the region is affected by numerous stock-water reservoirs (now limited to a maximum capacity of 20 acre-feet per reservoir by the state law (Wyoming State Engineer 1975)) and spreader systems on the small tributaries. Storage and diversion by these structures result in appreciable depletion through evapotranspiration and seepage. A flow rate of about 0.033 cfsm originates on every square mile within the region, but only about 0.014 cfsm runs out of the whole region. This is a depletion of about 58% from the drainages of about one square mile in size to the point at which the streams draining large areas exit the region. Although most streamflow is affected by stock ponds and spreader systems, experience has shown that very high peak flows (flows with a return period of 50 years or more, Table RB-5, Appendix B) are not noticeably reduced. The "flashy"nature of these prairie streams produces very high peaks of short duration. These are due to the high-intensity thunderstorms which supply the southern part of the region with most of the year's precipitation in most years.

The sediment-carrying capacity and erosive power of floods in ephemeral streams is extremely high. Even though the total volume of such floods is much less than that of mountain snowmelt peaks, the peak stages (heights of flood) of the plains streams are often much higher. The highest water-borne sediment concentrations occur during flood periods (see Table RB-6, Appendix B).

Erosion and sedimentation depend upon the energy of the rainfall and water flow, erodibility of the soil, and the protective influence of the vegetative cover. Water-borne sediment originates from sheet erosion and from gully and channel formation. Sheet erosion is caused by raindrop impact and storm runoff which develops rills and small unstable channels. Gullies begin as rills and are generally formed when intense rainstorms provide large volumes of highvelocity flow. L.M. Shown (personal communication 1977) found that sedimentation rates as measured from about 20 ranch ponds scattered through the mine-leased area in Campbell County varied from about 0 to almost 3 acre-feet per square mile per year. Hadley and Schumm (1961) found average rates as measured from about 80 ponds in the Upper Cheyenne River Basin (which covers most of the portion of Converse County in the region) to be 0.13 acre-feet per square mile per year from drainages in the Wasatch Formation, and to be 1.3 acre-feet per square mile per year from drainages in the Fort Union Formation.

Chemical quality of water in a stream continually changes as a result of varying amounts and sources of water. Water in alluvium of the region normally has a higher dissolved solids concentration than storm runoff (high flows dilute low stream flows originating in the alluvium). Salts are deposited by evaporation of low flows (normally from groundwater) in the stream channel.

Ranges in some of the major chemical constituents have been listed (Table RB-7, Appendix B) for streams which drain most of the region (Little Powder, Cheyenne, and Belle Fourche rivers) and on one which borders the region on the southwest (Salt Creek). Salt Creek drains the famous oil field at Midwest, Wyoming, and consequently its quality should be affected and the maximums shown in the table should be very high. The period of record of Salt Creek is many years longer than those of the other records listed, and therefore the large differences between maximums and minimums may be the result of this fact.

Ranges in fecal coliform count in colonies per 100 milliliters (followed by the transporting streamflow in cubic feet per second) are given for October 1975 through September 1976 in the annual streamflow data report of the U.S. Geological Survey as follows: 37,600 (1,360) to less than 1 (866 to 1,500) in the North Platte River below Casper and 8,500 (3,790) to 32 (1,650) in the river at Orin; about 2,000 (16) to less than 1 (0.43) in the Little Powder River about 50 miles north of Gillette; about 2,000 (18) to 80 (9.7) in the Cheyenne River (which was dry over half the year) near the state line; and 110 (44) to about 2 (10) in the Belle Fourche River at Devils Tower. The North Platte below Casper was sampled biweekly and the others about monthly. Fecal coliform count is a measure of water pollution by warm-blooded animals.

Water Use

The Wyoming State Engineer (1972) states that of the water presently consumed by man's activities in northeastern Wyoming, over 80% is used for irrigation. The consumption of irrigation water is variable depending upon crop types and climatic factors such as temperature, humidity, and radiation. Because of the limited precipitation in northeast Wyoming, dependable crop production requires irrigation to provide the necessary water. Most irrigation is by direct diversion from streams, and flood irrigation is the principal method of application. Sprinkler irrigation is gaining in popularity, and both surface water and groundwater are used as sources of supply for this type of irrigation.

In the Eastern Powder River Basin, dry farming is the usual practice, although some water-spreader systems are used for supplemental irrigation of hay meadows and pastures. Small amounts of surface water are presently used in coal operations, primarily as process or dust control water. Practically all process water diverted by industry is consumed.

Groundwater is considered the primary source of domestic and stock water in the region. Groundwater supplies municipal water for Gillette and Wright, and communities along the North Platte draw their water from the river. Groundwater is used in the secondary recovery of oil, and the petroleum industry is presently the

Secondary plants include: Sandberg bluegrass, prairie junegrass, threadleaf sedge *(Carex filifolia)*, Indian ricegrass, green needlegrass *(Stipa viriduala)*, bluebunch wheatgrass, cheatgrass *(Bromus tectorum)*, and plains pricklypear *(Opuntia* polycantha).

The big sagebrush-grass vegetation type is by far the most widespread shrub community in the region. Other shrub communities do occur, but occupy rather specific habitats. Big sagebrush may be present in some of these other shrub communities, but other species are more characteristic.

Silver Sagebrush (map symbol 4A) (36,900 acres)

The silver sagebrush shrub community is found on level to gently sloping floodplains of streams which run water during at least part of the growing season, or on land which receives additional water from overflow. Soils of these sites are deep, well drained and permeable, somewhat sandy or loamy, and usually not extremely saline or alkaline. Silver sagebrush may form rather dense stands and grows 2 to 3 feet tall. The predominant understory grass is western wheatgrass. Needle-and-thread, Sandberg bluegrass, mat muhly *(Muhlenbergia* squarrosa), blue grama, prairie junegrass, and threadleaf sedge are present to a lesser extent, especially on areas subject to moderate to heavy grazing pressure. On lightly grazed areas, wildrye *(Elymus* spp.), green needlegrass, and several species of bluegrass are present. Forbs are scarce. Occasionally, snowberry *(Symphoricarpos* spp.) shrubs are present.

Greasewood-saltbush (map symbol 5) (82,960 acres)

Another shrub community is present along stream channels, on flood-plains which receive additional water from overflow or runoff, and in areas where soils are moderately to strongly saline or alkaline. The shrub layer of this plant community is characterized by a moderate to heavy stand of black *greasewood (Sarcobatus vermiculatus)* with some scattered rubber *rabbitbrush (Chrysothamnus nauseousus)*. Other shrub species include: fourwing saltbush *(Atriplex canescens)*, Gardner *saltbush (Atriplex gardneri)*, and winterfat *(Eurotia lanata)*. Grasses include: inland saltgrass *(Distichlis stricta) squirreltail (Sitanion hystrix)* alkali bluegrass *(Poa juncifolia)* alkali sacaton *(Sporobolus airoides)*.

The three shrub communities (sagebrush, silver sagebrush, and greasewood-saltbush) form a vegetative mosaic with the grassland communities. Where the density of shrubs is low, the community may have the appearance of grassland; however, it is not known whether these areas are "true grasslands,"places where the growth of shrubs, particularly big sagebrush, is limited by specific factors. The only communities in the region where grasses and sedges are known to dominate are characterized by either high soil moisture, or shallow, stony soil, or sand dunes.

Ponderosa Pine Forest (map symbol 6) (328,400 acres)

Areas where trees are dominant are present in the region. The most widely distributed type is ponderosa pine *(Pinus* ponderosa) forest (Figure R2-27). This vegetation type is well distributed over the badlands-scoria region north and east of Gillette in Campbell County. It extends southward in a long, narrow band to the vicinity of Lusk where it swings west toward Douglas. A distinct area of ponderosa pine is present on the western edge of Converse County, east of Midwest. The distribution of ponderosa pine forest appears to be limited to the crests of sandstone, shale, and scoria outcrops.

Ponderosa pine is the principal tree species. It grows in stands which range from closed-canopy forests to savannahlike woodlands. The shrub species in the understory of the denser forest stands include skunkbush sumac, creeping *juniper (Juniperus horizentalis)*, and western snowberry *(Symphoricarpos* occidentalis). The herbaceous layer is composed mostly of grasses. Major species are green needlegrass, Sandberg bluegrass, prairie junegrass, and stony hills muhly. In open stands of ponderosa pine, silver sagebrush, green needlegrass, and sideoats grama *(Bouteloua curtipendula)* are the major understory species. On sites with coarser soils, bluebunch wheatgrass, little bluestem, and porcupine needlegrass *(Stipa* spartea) may be present.

Riparian Vegetation (map symbol 10) (224,500 acres)

This vegetation type occurs along drainages and adjacent to lakes, ponds, and springs where moisture accumulates in the soil (Figure R2-26). Some portions are periodically inundated, while other portions are much drier. Included in this type are groves of deciduous trees, meadows, marshlands, and open grasslands. This vegetative type occurs in alluvial valley floors in the region.

Broadleaf trees are present on some of the perennial stream floodplains (Cheyenne, Belle Fourche, Powder, and Little Powder rivers) and intermittent streams which flow eastward and northward from Campbell and northern Converse counties. The density of the trees ranges from scatterings of single trees, to fringing rows, to riparian woodlands extending several miles along the stream channel and 2 to 3 miles on either side of it. The latter type of forest is most prevalent on the eastern edge of the two counties. Plains *cottonwood (Populus sargentii)* is the characteristic tree for this vegetation type, although lanceleaf cottonwood *(P. acuminata)* may also be present. Other less common trees are sandbar willow *(Salix interior)*, coyote willow *(S. exigua)*, peachleaf willow *(S. amygdaloides)*, and boxelder *(Acer negundo)*.

Important grasses and forbs are: prairie *cordgrass (Spartina pectinata)*, tufted hairgrass *(Deschampsia caespitosa)*, slender wheatgrass *(Agropyron trachycaulum)*, western wheatgrass, inland sedge *(Carex interior)*, baltic rush *(Juncus balticus)*, arrowgrass *(Triglochin* spp.), and golden pea *(Thermopsis* spp.).

Soils on many of these riparian sites have high organic matter content. Some of the meadows are very productive and are mowed for wild hay or used for other agricultural purposes.

Aquatic Vegetation

Aquatic type refers to the vegetation associated with permanent pools along drainages, reservoirs, and ponds. Aquatic vegetation is limited to species which require wet ground but which can exist for long periods without standing water. Species include bulrush *(Scirpus* spp.), common *cattail (Typha latifolia)*, sedges, watercrowfoot *(Ranunculus aquatilis)*, and filamentous green algae. This vegetative type occurs in alluvial valley floors. This type is not delineated separately, but is included in the riparian type on the vegetation map.

Endangered and/or Threatened Species

No plants listed as endangered or threatened species have been identified in the region (Keenlyne 1977, *Federal Register* 1976).

A plant *(Aquilegia laramiensis)* found in the mountainous areas of southern Converse County is a candidate for the endangered or threatened list. It is not likely to be found in the semiarid environment of the Eastern Powder River Basin.

Each site proposed for mining or other development must be intensively inventoried by a qualified plant specialist to determine whether threatened or endangered plants exist.

FISH AND WILDLIFE

The region to be analyzed is in northeastern Wyoming and includes all of Campbell County and that portion of Converse County north of the North Platte River. The area includes 4,978,560 acres composed primarily of rolling plains, low mountains, rough breaks, and rocky ridges.

Vegetation in the region is diverse and ranges from pure grassland, to the dominant sagebrush-grassland type, to wooded drainages and timbered hills.

A wildlife distribution and density study is currently being conducted in the region by the Wyoming Game and Fish Department under Bureau of Land Management (BLM) contract. Information given below may change on the basis of data gathered.

Habitat Types

Below are listed the major habitat types and the wildlife species that are associated with each type. A complete list of wildlife species within the region is available at the BLM Casper District Office.

Aquatic

The aquatic habitat consists primarily of 47 scattered livestock reservoirs and 262.3 miles of intermittent streams, which support fisheries: black bullhead, green sunfish, stone cat, flathead, chub, carp, fathead minnow, longnose dace, goldeneye, northern redhorse, white sucker, longnose sucker, mountain sucker, river carp sucker, sturgeon chub, plains minnow, silvery minnow, channel catfish, shovelnose sturgeon, rainbow trout, brook trout, and bass.

Terrestrial

The location and relative size of each habitat type listed below is illustrated on the regional vegetation map (Map 5, Appendix A).

Sagebrush-Grass (4,188,150 acres). Horned lark, lark bunting, meadowlark, sage thrasher, Brewer's sparrow, green-tailed towhee, sage sparrow, sage grouse, sagebrush vole, deer mouse, least chipmunk, white-tailed jackrabbit, black-tailed jackrabbit, mountain cottontail, desert cottontail, coyote, red fox, badger, mule deer, and pronghorn antelope.

Ponderosa Pine (328,400 acres). Pinon jay, gray jay, chickadee, brown creeper, red-breasted nuthatch, wild turkey, mourning dove, bushy-tailed wood rat, porcupine, beaver, white-tailed deer, mule deer, and elk.

Riparian (224,500 acres). Western kingbird, goldfinch, yellow warbler, robin, killdeer, willet, avocet, spotted sandpiper, lesser yellowlegs, coot, eared grebe, mallard, American widgeon, pintail, blue-winged teal, green-winged teal, common merganser, canvasback, marsh hawk, vagrant shrew, wandering shrew, mink, muskrat, long-tailed weasel, raccoon, striped skunk, white-tailed deer, mule deer, snapping turtle, painted turtle, garter snake, bullfrog, leopard frog, and tiger salamander.

Sandhills Grassland (90,100 acres). Horned lark, vesper sparrow, lark bunting, savannah sparrow, grasshopper sparrow, mourning dove, Hungarian partridge, western harvest mouse, Ord's kangaroo rat, hispid pocket mouse, Wyoming pocket mouse, northern pocket gopher, Richardson's ground squirrel, thirteen-lined ground squirrel, striped skunk, desert cottontail, red fox, coyote, and pronghorn antelope.

Greasewood (80,700 acres). Loggerhead shrike, yellow warbler, long-tailed weasel, badger, coyote, red fox, striped skunk, desert cottontail, least chipmunk, and mule deer.

Silver Sagebrush (36,900 acres). Horned lark, lark bunting, deer mouse, long-tailed weasel, desert cottontail, pronghorn antelope, and mule deer.

Scoria Grassland (27,300 acres). Horned lark, grasshopper sparrow, mourning dove, western harvest mouse, Ord's kangaroo rat, striped skunk, desert cottontail, red fox, coyote, mule deer, and pronghorn antelope.

Saltbush-Greasewood (2,260 acres). Loggerhead shrike, horned lark, yellow warbler, black-tailed jackrabbit, black-tailed prairie dog, northern pocket gopher, red fox, coyote, mule deer, and pronghorn antelope.

Playa Grassland (250 acres). Savannah sparrow, meadowlark, mourning dove, Hungarian partridge, northern pocket gopher, western harvest mouse, hispid pocket mouse, deer mouse, Richardson's ground squirrel, striped skunk, and long-tailed weasel.

Raptors are seen foraging in all of the habitat types listed. A complete list of the raptor species that may be observed in the region is available from BLM Casper District Office.

Fish

Introduction

There are an estimated 262.3 miles of stream in the region which support some type of fish, primarily nongame. These include 177 miles of the Little Powder River, an approximate 11-mile section of the Powder River, 96.3 miles of the Belle Fourche River, 18 miles of Caballo Creek, and 20 miles of Little Thunder Creek (personal communication, John Mueller, Wyoming Game and Fish 1978). The locations of the streams mentioned are shown on Map 1, Appendix A.

Nongame

The nongame fish species occurring most frequently in the region are listed under the aquatic habitat discussion at the beginning of this section.

Game

Many of the livestock reservoirs and some streams contain stocked or native populations of trout, bass, black bullhead, and/or green sunfish.

Sensitive Species

There are four species of fish which the Wyoming Game and Fish Department lists as rare (1977), and which may occur in the region: the shovelnose sturgeon, the sturgeon chub, the goldeneye, and the silvery minnow. All of these species may be found in the Powder River or Little Powder River.

Endangered and/or Threatened Species

No endangered or threatened fish species are known to occur in the Eastern Powder River Basin.

Wildlife

Birds

Nongame. The songbird species most frequently encountered in the region are included in the list of habitats at the beginning of this section. Densities for nongame birds are illustrated in Table R2-8.

The rolling plains of the region provide excellent hunting habitat for raptors. Raptor numbers in the region are restricted due mainly to the scarcity of preferred nesting areas, which are located primarily along wooded drainages. Both golden and bald eagles, an endangered species, winter in the region, but only the golden eagle is a yearlong resident. From figures in Table R2-8, raptor density is estimated at 3.6 per square mile.

Game. Sage grouse is the most important game bird species in the region. Sage grouse have been observed on 4 of the existing mine leases; one of the sites has sage grouse strutting grounds within the lease boundaries. Doves are the most abundant game bird species in the region. Estimates from inventories conducted on existing mine sites range from 5 to 25 pair per 100 acres (Table R2-8). Other game birds are found in scattered populations or require specialized habitat. Included in this category are sharp-tailed grouse, wild turkey, Hungarian partridge, ring-necked pheasant, chukar, snipe, lesser sandhill crane, American coot, and waterfowl.

Sensitive Species. The Wyoming Game and Fish Department lists only the burrowing owl as rare in the region (1977).

Endangered and/or Threatened Species. Three endangered bird species which may occur in the Eastern Powder River Basin are the bald eagle, which may be a winter resident, and the peregrine falcon and whooping crane, which are possible migrants (personal communication, Harry Harju, Wyoming Game and Fish Department 1978).

Mammals

Nongame. The most common nongame mammals found in the region are noted with the habitat types at the beginning of this section.

Game. The Wyoming Game and Fish Department estimates that there are 48,000 pronghorn antelope in the Eastern Powder River Basin (personal communication, Roger Wilson and Bill Helms, Wyoming Game and Fish Department 1977). This is nearly 20% of the total antelope population in the state of Wyoming. The estimated antelope density for the region is derived from Table R2-9 and is 20.8 antelope per square mile. (See Map 6, Appendix A.)

The total mule deer population in the region is estimated by the Wyoming Game and Fish Department to be 30,000 (ibid.). The average density of deer inhabiting the region is derived from Table R2-9, and is three per square mile.

Endangered and/or Threatened Species. The only mammalian species considered endangered that may exist in the region is the black-footed ferret. Recent sightings within the region have been documented (Clark 1977), and those sightings classified as positive are as follows: a sighting by J. Heasley on July 29, 1974, 10 miles west of Reno Junction in T. 43 N., R. 73 W., Section 5, in Campbell County; and a sighting by J. Tate on May 15, 1976, in T. 43 N., R. 70 W., Section 30, in Campbell

TABLE R2-8

BIRD DENSITIES ON EXISTING AND PROPOSED MINE SITES

Mine	Nongame	Game	Raptors	Remarks
Belle Ayr	12.6/acre	D.-320/sq. mi.*	5.6/sq. mi.	Raptor nesting occurring
Black Thunder	NA	S.G.-3.9/sq. mi.**	NA	
Caballo	6.0/acre	D.-7.4/sq. mi.*	0.8/sq. mi.	
Coal Creek	3.0/acre	NA	NA	Raptor nesting occurring
Cordero	NA	NA	NA	
Dave Johnston	NA	NA	NA	
Eagle Butte	2.7/acre	D.-64/sq. mi.*	5.3/sq. mi.	23 pairs waterfowl observed
East Gillette	NA	NA	NA	
Kerr McGee #16	NA	NA	NA	
Jacob's Ranch	NA	NA	NA	
Pronghorn	NA	NA	NA	
Rawhide	NA	S.G.-20/sq. mi.**	1.25/sq. mi.	
Rochelle	1.0/acre	NA	NA	
Wyodak	NA	NA	NA	
Buckskin	NA	NA	4.8/sq. mi.	Waterfowl- 6.6 sq. mi.
Average Density	5.1/acre	S.G.-11.9/sq. mi. D.-130.5/sq. mi.	3.6/sq. mi.	

Source: Information obtained or extrapolated from data contained in the mining and reclamation plans for each site.

Note: Wildlife density figures are available only where studies have been required as a prerequisite for mineral development. Wildlife densities in the region as a whole is the subject of a current Wyoming Game and Fish Department study. The figures shown above may change as data are received.

* D.--Dove

** S.G.--Sage Grouse

NA = not available

TABLE R2-9

BIG GAME DENSITIES FOR EXISTING AND PROPOSED MINE SITES

Mine	Permit Area Square Miles	Antelope*	Deer*
Belle Ayr	9.5	59.0	5.4
Black Thunder	11.5	18.3	1.7
Caballo	10.4	10.65	0.02
Coal Creek	15.0	21.4	1.9
Cordero	13.1	3.8	4.3
Dave Johnston	17.2	NA	NA
Eagle Butte	6.5	67.0	3.8
East Gillette	6.9	10.5**	.8**
Kerr McGee #16	1.5	NA	NA
Jacob's Ranch	7.8	7.1	1.9
Pronghorn	1.3	24.5	10.4
Rawhide	9.3	6.0	3.0
Rochelle	17.4	11.3	2.1
Wyodak	5.1	NA	NA
Subtotal (sq. mi.)	132.5		
Buckskin	2.7	9.8	0.5
TOTAL (sq. mi.)	135.2		
Average Density		20.8	3.0

Source: Information obtained or extrapolated from data contained in the mining and reclamation plans for each site.

Note: Wildlife density figures are available only where studies have been required as a prerequisite for mineral development. Wildlife densities in the region as a whole is the subject of a current Wyoming Game and Fish Department study. The figures shown above may change as data is received.

* Per square mile.

** Information submitted by Kerr McGee for the East Gillette Mine includes data for the adjacent #16 Mine.

NA = not available

County. The black-footed ferret is closely associated with prairie dog towns (see Map 7, Appendix A), which are considered as primary ferret habitat.

Reptiles and Amphibians

General. The following reptile species may be found in the region: prairie rattlesnake, bull snake, milk snake, plains garter snake, yellow-bellied racer, horned lizard, sagebrush lizard, snapping turtle, and the painted turtle. Amphibians which may occur in the region are the spadefoot toad, Great Plains toad, Rocky Mountain toad, boreal chorus frog, bullfrog, leopard frog, and the tiger salamander.

Endangered and/or Threatened Species. No endangered or threatened reptile or amphibian species are known to occur in the Eastern Powder River Basin.

CULTURAL RESOURCES

Cultural resources constitute integral and nonrenewable portions of the human environment—fragile and limited evidence of past human activity, which is reflected in sites, structures, artifacts, objects, ruins, works of art, or documentation. Cultural resources represent a continuum of events which are discussed in terms of prehistoric, ethnohistoric, and historic values. For purposes of this document, prehistoric cultural resources represent Indian utilization of a region prior to the influences of European contact. The Indian utilization of a region after the influence of European contact is the ethnohistoric period, and historic resources are those representing European/American exploration and settlement.

This discussion is limited, where possible, to the Eastern Powder River Basin of Wyoming. It should be noted that the cultural resources of an area are only slightly influenced by political boundaries, and in this case political boundaries have been present only during the most recent historic period. Actual consideration of cultural resources must be conducted along the geographic or ecological boundaries which have influenced cultural development.

Cultural resource inventories in the region have been scattered and sporadic until recently. Many of the recent cultural resource inventories have been undertaken to comply with Section 106 of the Historic Preservation Act of 1966 and Section 2(b) of Executive Order 11593, "Protection and Enhancement of the Cultural Environment"

Prehistoric

Before 1973, only two systematic professional archeological studies had been conducted in the region. The River Basin Survey conducted the first of these in 1949 for the proposed Moorehead Reservoir (Wheeler 1949). Even though several sites of value were identified, no investigations of consequence resulted. The second was the excavation of the Ruby site in 1971 (Frison 1971). Since 1973, many archeological investigations have been conducted for various coal and uranium mines, oil well locations, transmission lines, and roads to comply with Section 106 of the Historic Preservation Act and with Executive Order 11593. Even though minor excavations have been conducted on identified sites, only preliminary reports are available; however, further work is in progress. The Wyoming State Archeologist has completed a report on the "Archeology of the Eastern Powder River Basin, Wyoming"compiling available data which provides supporting documentation for this section (Zeimens and Walker 1977).

The prehistoric chronology developed for this region is based on excavations within larger geographic and ecological boundaries. To date, there have not been sufficient studies conducted to fully develop a chronology without depending upon studies conducted outside the region. The first chronological sequence for the northwest plains was developed by Mulloy (1958), and studies conducted since have led to a revision of the chronology by Frison (1978). The chronology which Frison has presented is defined in terms of five broad periods: Paleo-Indian, 11,200 to 7,500 years ago; Early Plains Archaic, 7,500 to 5,000 years ago; Middle Plains Archaic, 5,000 to 3,000 years ago; Late Plains Archaic, 3,000 to 1,700 years ago; and Late Prehistoric, 1,700 to 300 years ago (Zeimens and Walker 1977). This chronology is summarized in Table R2-10.

Within the region, about 200,500 acres have been inventoried by professional archeologists, representing a 4% nonrandom, nonstratified sample. Not all environmental zones identified in the region are represented in this sample, nor have excavations been conducted on a representative number of sites. These inventories have identified 246 sites, most of which are on lands covered by approved mining plans. During each plan's review, the significance of individual sites involved has been assessed, and adequate stipulations developed for the recovery of archeological data. Archeological evaluation has indicated that all available data has been recovered from 120 known sites (Zeimens and Walker 1977). Complete information has yet to be recovered from 126 sites. Cultural affiliation has been assigned to 29 sites in the region based on projectile point types on 25 sites, on carbon-14 (C-14) dates at 3 sites, and on pottery types found at 1 site. Some sites represent more than one period. Nineteen Late Prehistoric period sites have been identified by diagnostic projectile points and 3 others by C-14 dates. Five of these sites also contained diagnostic materials indicating earlier occupation. Nine sites representing the Late Plains Archaic period have been identified, 1 by a C-14 date, and 8 others based on diagnostic projectile points. The Middle Plains Archaic and Early Plains Archaic periods are represented by diagnostic projectile points recovered from 1 site. The Paleo-Indian period is represented by 3 sites. One is an Eden bison kill site where excavations and analysis are in progress by the University of Wyoming. Hell Gap points were recovered from the other 2 sites during inventory investi-

TABLE R2-10

CHRONOLOGICAL SEQUENCE FOR NORTHWEST PLAINS

Period	Date B.P. (before present)	Projectile Point Style or Cultural Group Northeast Wyoming	Evidence Eastern Powder River Basin
Ethnohistoric	300 to 100 years ago	Teton Dakota (Sioux) Arapaho Cheyenne Crow Shoshone	Historic record
Late Prehistoric	1,700 to 300 years ago	Comanche Shoshoni Plains Apache Kiowa Crow Avonlea projectile points	Ethnographic information Pottery from 1 site Surface evidence from 22 sites 48 CA 7, 1,320 ± 100 BP 48 CA 56, 1,590 ± 110 BP 48 CA 302, 1,670 ± 135 BP
Late Plains Archaic	3,000 to 1,700 years ago	Corner-notched projectile points	One excavated site Surface evidence from 9 known sites 48 CA 104, 2,040 ± 90 BP
Middle Plains Archaic	5,000 to 3,000 years ago	McKean	Surface evidence from 1 site
Early Plains Archaic	7,500 to 5,000 years ago	Large side-notched projectile points	Surface evidence from 1 site
PaleoIndian	11,200 to 7,500 years ago	Eden Hell Gap Agate basin Folsom Clovis	One buried site Surface evidence from 2 sites Private collections

Source: Zeimens and Walker 1977

gations. Analysis of known sites and private artifact collections indicates that a complete temporal range of occupation is present in the region. Unfortunately, much of the evidence is in the form of isolated surface finds, and not sites with buried cultural materials needed to establish a better chronology for the region. As individual sites are fully studied, more complete data will become available.

Identified sites can be divided into ten categories: (1) stratified sites, (2) bone beds, (3) stone circles, (4) rock art, (5) burials, (6) rock shelters, (7) ceramic sites, (8) quarries, (9) fire pit sites, and (10) concentrations of worked lithic (tool stone) material. Presently 4 stratified sites have been identified, but none has been fully studied. There are 6 sites known to contain buried levels of bison bone as well as definite cultural materials. One of these (the Ruby site) has been excavated and reported, and 2 others have detailed excavations and analysis in progress. Forty-three sites contain stone rings or tipi rings. Only 1 rock shelter containing evidence of occupation has been identified, and only 2 rock art sites are known. The 1 recorded prehistoric burial was presented to the University of Wyoming in a cardboard box and is thus of little archeological value. Ziemens and Walker (1977) reported 5 sites known to contain ceramics, unfortunately, none of the sites has provided ceramics in definitive context. The 13 tool-stone quarries which have been recorded are located on gravel-capped ridgetops where tool stone was gathered from the surface; no evidence of excavation or quarrying to recover tool stone has been identified. The remaining sites consist of concentrations of worked lithic material or evidence of fire pits.

Until more studies are conducted, the actual significance of these sites cannot be evaluated. As further archeological work progresses, more sites within each category will be identified. Many known sites are deeply buried and are only discovered because of modern arroyos. Isolated bison bones which may date to 10,000 years ago are found exposed 10 to 15 feet below the surface in some arroyos. Thus much of the evidence for occupation is not evident on the surface.

Archeological investigations have provided the information needed to make a number of assumptions concerning settlement pattern or prehistoric site locations within the region. Since these assumptions are based on limited data, they are very general. As ongoing work is completed, more information will become available on settlement pattern systems within each temporal period. The first assumption is that the greatest site density should be in areas with the greatest diversity of wildlife and vegetation along major drainages or in areas of greatest topographic relief. A major problem, however, is that these areas have the least chance of being exposed due to soil deposition, which may be 10 to 15 feet thick, and vegetative cover. Site density should be the lowest in large, flat, open grasslands with little topographic relief; however, these areas have the greatest chance of discovery. In areas of high site density, much of the evidence for prehistoric occupation will only be identified when vegetative cover and topsoil are removed.

Due to the small sample of fully excavated sites in the region, no one time period or cultural affiliation is more significant than another. Any site containing datable cultural materials is very significant in the Eastern Powder River Basin.

Ethnohistoric

Material remains of tribes who occupied the Eastern Powder River Basin are studied along with other archeological sites when identifiable. Available ethnographic data allows some tribal identification from A.D. 1400 until A.D. 1880, although actual historic accounts are very scanty before 1850. Tribal distribution and density can be seen as a series of population movements drawn onto the plains by high bison populations and away from the plains in years of low bison populations. The grasslands have dominated the central North American continent for thousands of years, "...sighing to the periodic rhythm of changes in rainfall, luring peoples out with the promise of incredibly rewarding hunting, only to dry and expell them again"(Reher, from Zeimens and Walker 1977, p. 135).

Reconstructed tribal distributions are presented in Figures R2-21, through R2-24. Actual physical evidence of these occupations should become evident as additional archeological investigations are conducted.

Historic

The first traveler known to have entered the region was Francois Antoine Larocque of the Northwest Company who entered the northwest corner of Campbell County on August 2, 1805, while traveling up Powder River. The bulk of his travels were in Montana, and no sites related to this exploration have been located.

The second known party and the first to have a direct effect upon later activities was the group of American Fur Company "Astorians"who crossed northern Campbell County in August of 1811. Their journey followed the divide between Powder River and the Little Missouri; however, no physical evidence of their presence has been recognized.

Robert Stuart led the returning "Astorians"in 1812 and is credited with the discovery of the North Platte-South Pass transcontinental land route best known as the Oregon Trail. This trail served as a major transcontinental route until 1862, and still retains national importance.

Pack trains of traders and trappers moved frequently over the Oregon Trail in the 1820s and 1830s. In 1842, they took the first wheeled vehicle, a four-pounder cannon, over the route. Soon, trade caravans regularly included a variety of carts and wagons. By the time frontier farmers developed an interest in settling the valleys of Oregon and California, the route was well known and marked by signs of travel.

The first party of settlers to California followed the trail in 1841, those to Oregon in 1842, the first Mormon settlers to Utah in 1847, and the California gold miners in

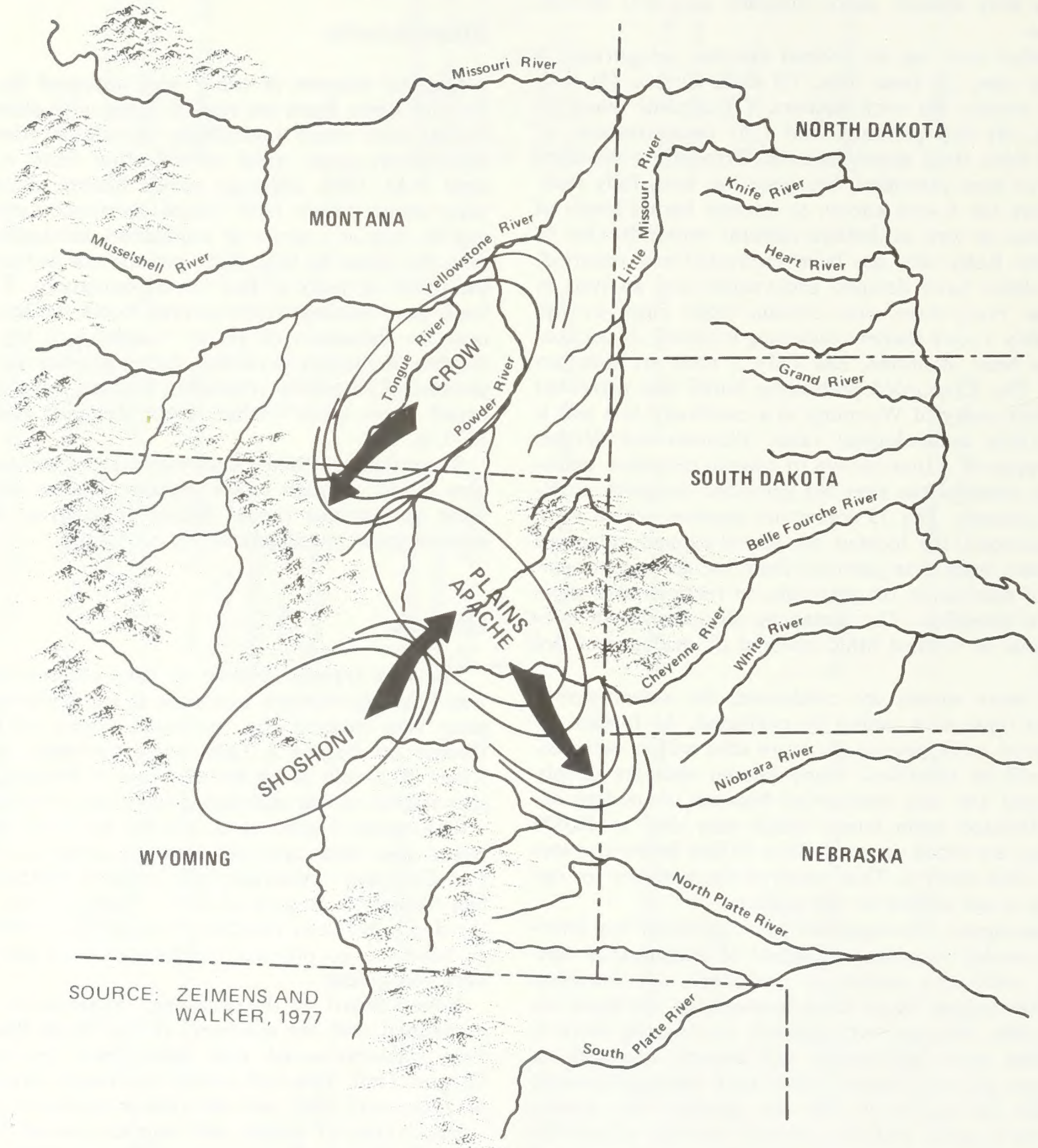


Figure R2-21
TRIBAL DISTRIBUTION OF THE POWDER RIVER BASIN, A.D. 1400 - 1600

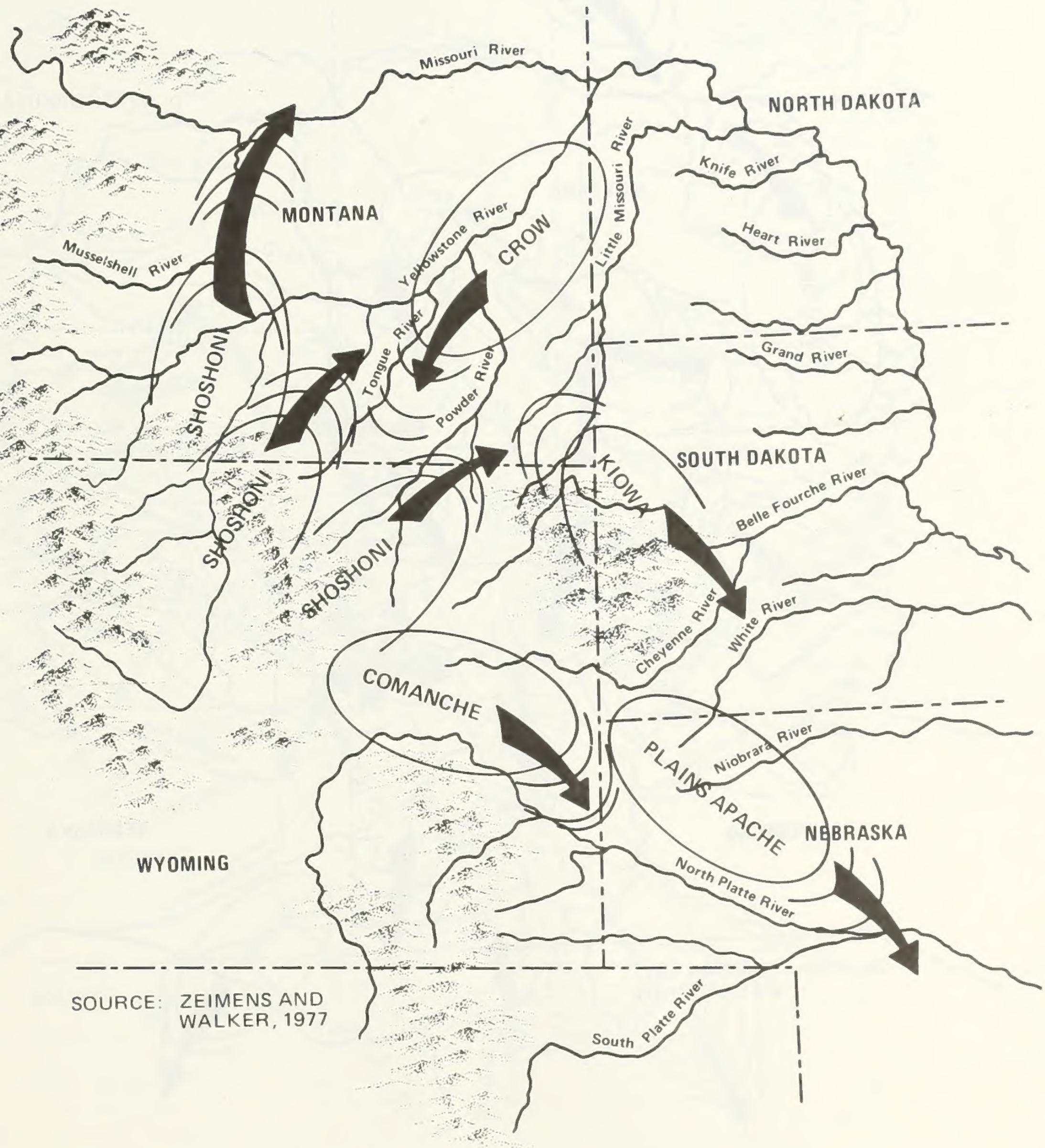


Figure R2-22
TRIBAL DISTRIBUTION OF THE POWDER RIVER BASIN, A.D. 1600 - 1700

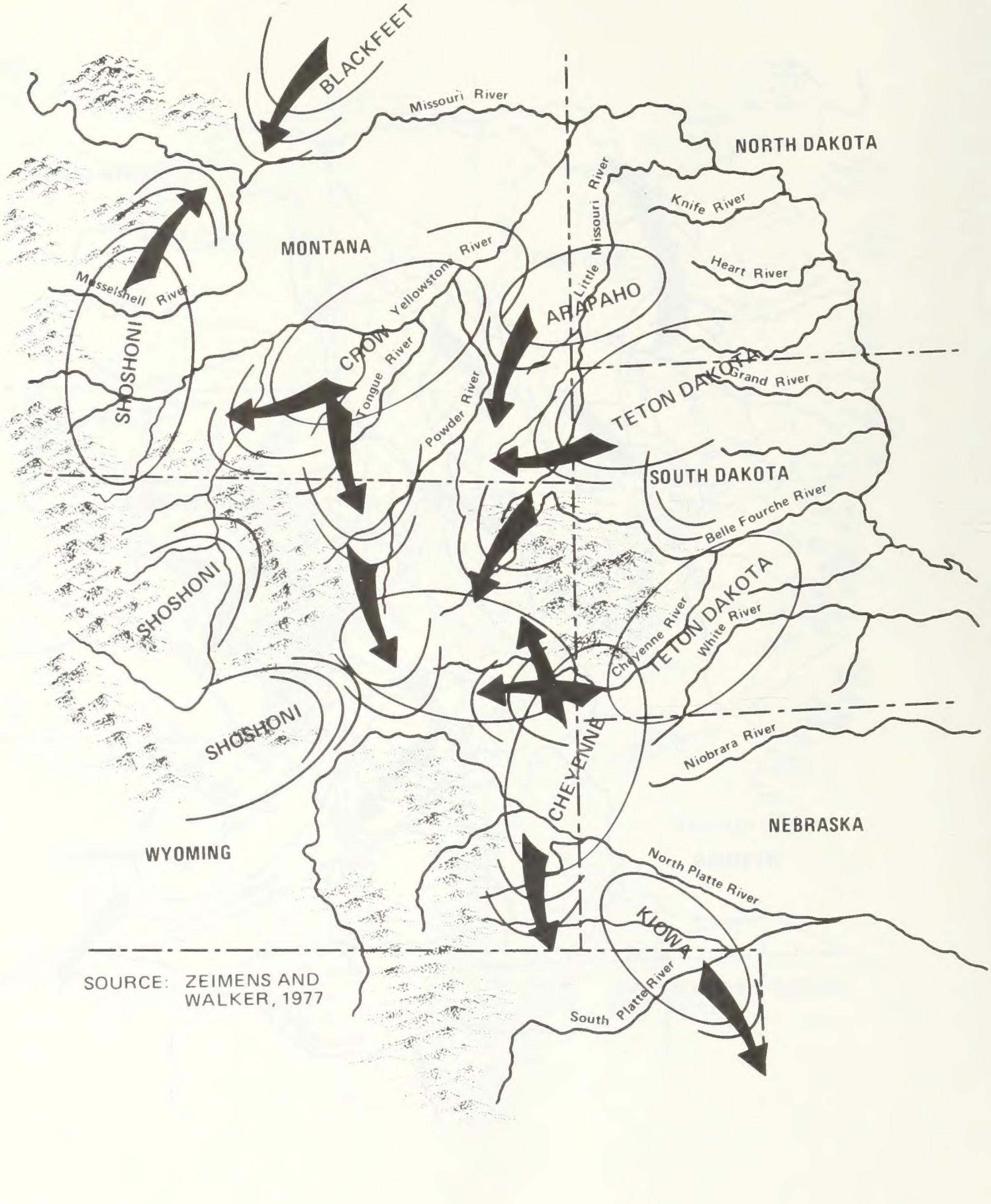


Figure R2-23

TRIBAL DISTRIBUTION OF THE POWDER RIVER BASIN, A.D. 1700 - 1800

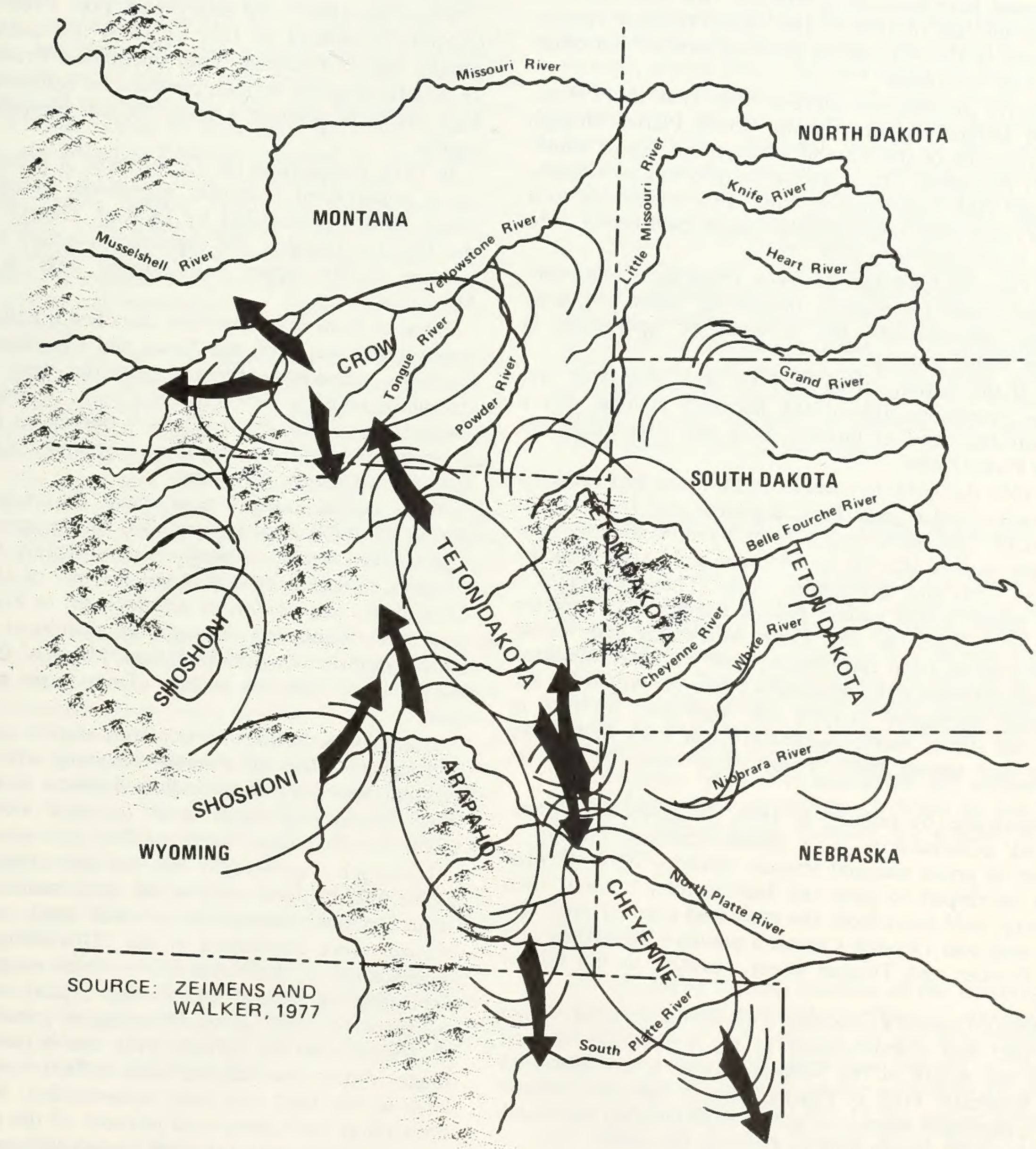


Figure R2-24
TRIBAL DISTRIBUTION OF THE POWDER RIVER BASIN, A.D. 1850

1848. As these travelers poured over the route, trading posts, ferries, and toll bridges prospered.

A transcontinental mail route operated from 1856 to 1858. The main overland stage line used this route from 1858 to 1862. The short-lived Pony Express of 1860 to 1861 passed here also, along with the first transcontinental telegraph line of 1861 to 1867. Each of these systems used some of the old trading posts as stations and established some new ones.

Extensive government surveys from 1856 to 1859 developed alternate routes up the South Platte, through lower portions of the Laramie Range and across southwestern Wyoming. The stage line moved to a new southern route (the Overland) in 1862. Few emigrants took the old route after 1862 until the region itself began to be settled in the late 1870s.

The Oregon Trail did, however, serve as a main transportation route for military operations, when the army assumed responsibility for a series of operations in Powder River country.

All of this activity from 1812 to 1865, plus later supportive operations against the northern Indians, left a concentrated band of historic trails and sites along the North Platte River.

By 1863 the gold discoveries in Montana had caused a gold rush. In that year John Bozeman and John Jacobs set out to "pioneer"a wagon route to more directly connect the eastern side of the Montana gold area with the Oregon Trail and the eastern states. They publicized a route which linked known Indian, trapper, and explorer trails; it fronted the Big Horn Mountains and would allow wagons from the Oregon Trail to enter Montana without traversing the mountains (Map 12, Appendix A). Bozeman attempted to pilot one train over his trail in 1863, but it met hostile Indians at Clear Fork of Powder River and turned back. Four trains went through in 1864.

Meanwhile, by January of 1865, the government considered construction of a transcontinental railway a matter of prime national interest (Murray 1974). A plan soon developed to keep the Indians busy in their own country, well away from the projected railroad line. The first step was General Connor's punitive expedition into the Powder and Tongue River country, in the fall of 1865.

During Connor's activities, a civilian contractor, James Sawyer, was commissioned to lay out a wagon road from the mouth of the Niobrara River to connect with the Bozeman Trail at Powder River. Sawyer's column did a minimum amount of actual road building and theirs was the only wagon train to ever use the route.

In 1866, the government sought to pacify as many tribes as possible through presents and negotiations at Fort Laramie, while expanding its diversionary efforts and answering demands of Montana settlers by sending a force of regulars to garrison Fort Reno and to build at least two new posts along the Bozeman Trail.

Notable engagements were fought at Crazy Woman Creek and at Fort Phil Kearny. The best known is the Fetterman disaster in which Captain Fetterman led 81 men to their deaths in a Sioux and Cheyenne ambush less than 5 miles from the post. When skilled and seasoned combat veterans entered the picture they bested the Sioux in every skirmish, the most notable being the Wagon Box Fight of August 2, 1867. Several minor battles were also fought along the Bozeman Trail within the region.

When the rails were safely past Fort Fred Steele in southern Wyoming in July of 1868, the army quickly phased out its Bozeman Trail operations. From 1868 to 1876 there was not enough pressure for settlement of the high plains to warrant a major Indian campaign in the region.

In 1874, troops from the Department of Dakota escorted a government scientific expedition to explore the Black Hills. Commanded by Lt. Col. George Custer of the 7th U.S. Cavalry, the expedition reached the eastern portion of the region and camped near Inyan Kara Mountain.

Reports from the expedition launched a gold rush that precipitated war with the Sioux and Cheyenne in 1876. In these campaigns, primary operations were under the command of Brig. Gen. George Crook, commanding the Department of the Platte. Crook's operations substantially ended the Indian question as a serious military problem in what is now Wyoming.

With hostile Indians gone from the region by the spring of 1878, and the presence of the army insuring against their return, several changes rapidly took place. Construction activity during the summer of 1878 at Fort McKinney, and continued development at Fort Laramie and Fort Fetterman brought in additional freighters, supply contractors, and workmen. Many of these people stayed on to form the nucleus of settlement around each post.

Commercial buffalo hide hunters moved into the area and rapidly killed off animals remaining after 8 years of concentrated hunting by Indians between 1868 and 1876. Two hide-drying yards were operated along Powder River but their exact locations have not been identified.

Livestock was brought into the area along the North Platte by 1843, and each of the ferry stations, and later stage stations, maintained a small herd; actual cattle ranches were established in the 1870s along the feeder creeks south of the North Platte. Open range cattlemen, depending on eastern and foreign capital, rapidly filled the range by 1879, taking advantage of grazing resources no longer used by buffalo. This was a period of open range, rather than deeded land, a factor causing problems as the land was later homesteaded. Many of the open range operations used portions of the region; however, no major operations are known to have established home ranches within the area.

The Rock Creek Stage Company opened operations along the Bozeman Trail in 1877 to serve the growing population. Four stations were constructed at watering points in the region. One was operated by Mike Henry at Brown's Spring. Other stations were constructed at Sage Creek, Sand Creek, and Antelope Creek. Shortly after stage operations began, a military telegraph was constructed along the Bozeman Trail.

After 1880, homesteaders began settling the bottomlands and water sources, forming small ranches not backed by outside capital, and holding title to their base operations. These small ranches came into conflict with the open range operations over use of open public lands, which led to the Johnson County War of 1892.

Railroads arrived late in the region. The Fremont, Elkhorn, and Missouri Valley Railroad (later part of the Chicago and North Western system) reached the Douglas townsite on August 22, 1886 (Frary 1974). Lots were auctioned off on August 29, 1886, and Douglas became a town of 1,600 within 90 days (Murray 1974). The Burlington and Missouri Railroad extended its tracks across Campbell County, reaching the Gillette area in 1891. A tent town called Donkey Town was established for the construction men. Civil engineer Edward Gillette surveyed a shorter route which ran north of Donkey Creek and saved the expense of 30 bridges. For this service, the town which was established on Rock Pile Draw was named Gillette.

With rail service and the introduction of sheep to the region after 1891, homesteading began to take up most of the dryland areas and change the public range into private holdings. Both Douglas and Gillette became business centers for livestock shipping and homestead operations. The dry years and bad economic conditions of the 1930s were the final blows to many homesteaders, and the region's population decreased. During the 1930s, the federal government bought back many of the dryland homesteads and established the national grasslands system.

Some coal mining had been conducted on outcrops along the North Platte by Oregon Trail travelers. After railroads entered the region, several small coal operations developed, both along the Platte and in the Gillette area. Coal was mined in the Minturn district east of Gillette for local and railroad use. In 1923 the Peerless Mine was established on the Roland and Smith coal beds. The Wyodak Mine, established in 1922, is the oldest operating surface mine in the region. Large-scale coal development began in the 1970s.

The oil industry was active in the region by 1915. However, large-scale oil and gas activity did not develop until the 1950s.

Physical evidence of homesteads is present throughout the region, and varies from occupied homes to shallow depressions indicating former structures of some kind. Physical evidence of early coal and oil development is also present throughout the region.

National Register Sites

Presently, none of the archeological or historic sites identified in the Eastern Powder River Basin of Wyoming has been listed on the National Register of Historic Places (*Federal* Register 1977). Wyoming's State Historic Preservation Officer identified eleven sites eligible for nomination to the National Register on the state inventory: Brown's Spring, Sage Creek Station, Bozeman Trail, LX Bar Ranch, Antelope Springs, Ruby Site, Mooney Site, Norfolk Petroglyphs, 48 CA 12, 48 CO 52, and 48 CO 305.

VISUAL RESOURCES

The characteristic landscape of the Eastern Powder River Basin consists of open country: grass- and sage-covered plains, low hills, and scattered buttes. Water is rarely seen. Scattered areas of rough terrain supporting ponderosa pine and juniper, and red coloring in landforms provide occasional variety in the natural landscape. There are also areas of altered landscape in the basin, such as oil fields, urban areas, and mines.

Based on the Visual Resource Inventory and Evaluation System (U.S. Department of the Interior, Bureau of Land Management Manual 6300), visual resource management (VRM) classes have been identified for Campbell and northern Converse counties. These classes are delineated on Map 8, Appendix A. An explanation of the VRM system and the analysis from which these classes have been taken appear in Appendix B. Figures R2-25 through R2-29 illustrate the characteristic landscape and VRM classes found in the region.

RECREATION RESOURCES

About 75% of the land surface in the Eastern Powder River Basin is privately owned. Consequently, less public land is available for outdoor recreation than in other parts of Wyoming, and access to it is limited. The national forests and recreation areas on the fringes of the basin (Figure R2-30) absorb much of the recreation pressure created by local residents. Visitor use data are shown in Table R2-11 and in Appendix B.

A common unit of measurement for recreation is a visitor day which represents 12 hours in one activity. Three people canoeing together for 4 hours totals one visitor day.

Hunting

The big game hunting resource of the Eastern Powder River Basin is of national significance. Antelope, mule and white-tailed deer, and elk are the most plentiful and sought-after big game. Eighteen percent of the state's antelope harvest and 12% of the mule deer harvest occur in Campbell County. In 1976, 17,281 people hunted antelope within the Eastern Powder River Basin (Table R2-12), representing 42,529 hunter days. Nearly 85% of the antelope hunters were nonresidents. Deer hunters in the basin numbered 11,298, representing 41,933 hunter days. Over 67% of the deer hunters were nonresidents. Elk, which are not as abundant as antelope and deer, were hunted by 120 people, representing 432 hunter days. Over 88% of the elk hunters were residents (personal communication, Harry Harju, Wyoming Game and Fish Department 1976). The number of small game hunters is low, because the areas where rabbits and game birds

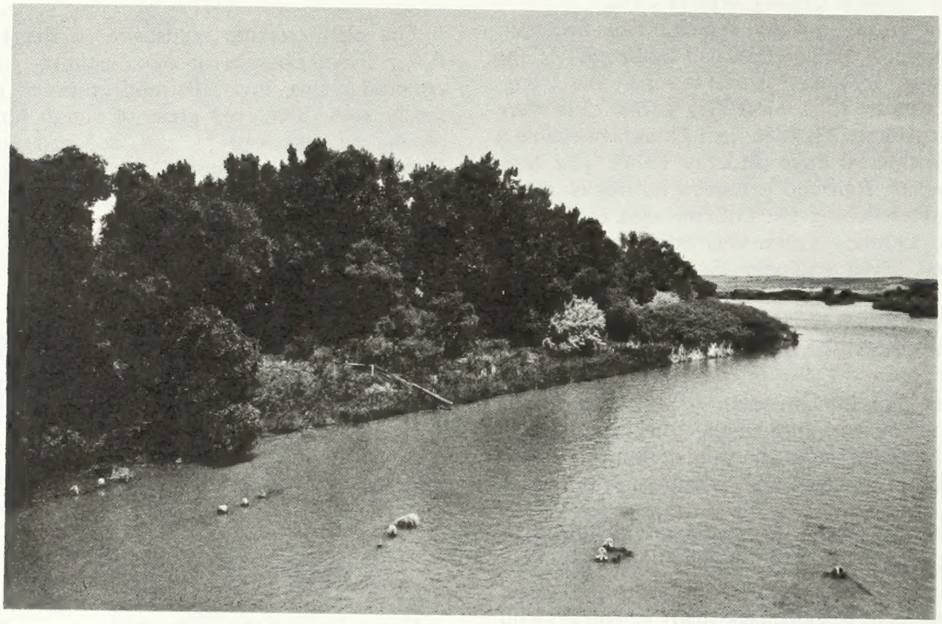


FIGURE R2-25

NORTH PLATTE RIVER--CLASS II

FIGURE R2-26

PINE-COVERED HILLS--CLASS III

FIGURE R2-27

ROLLING PLAINS--CLASS IV

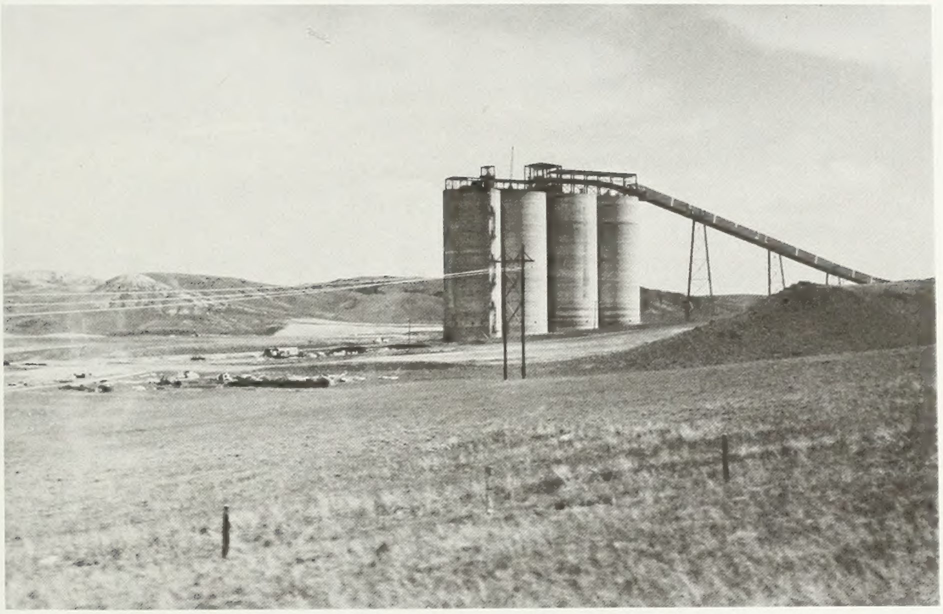


FIGURE R2-28

INTRUSION--CLASS V

Figure R2-29

Regional Vegetation - Playa

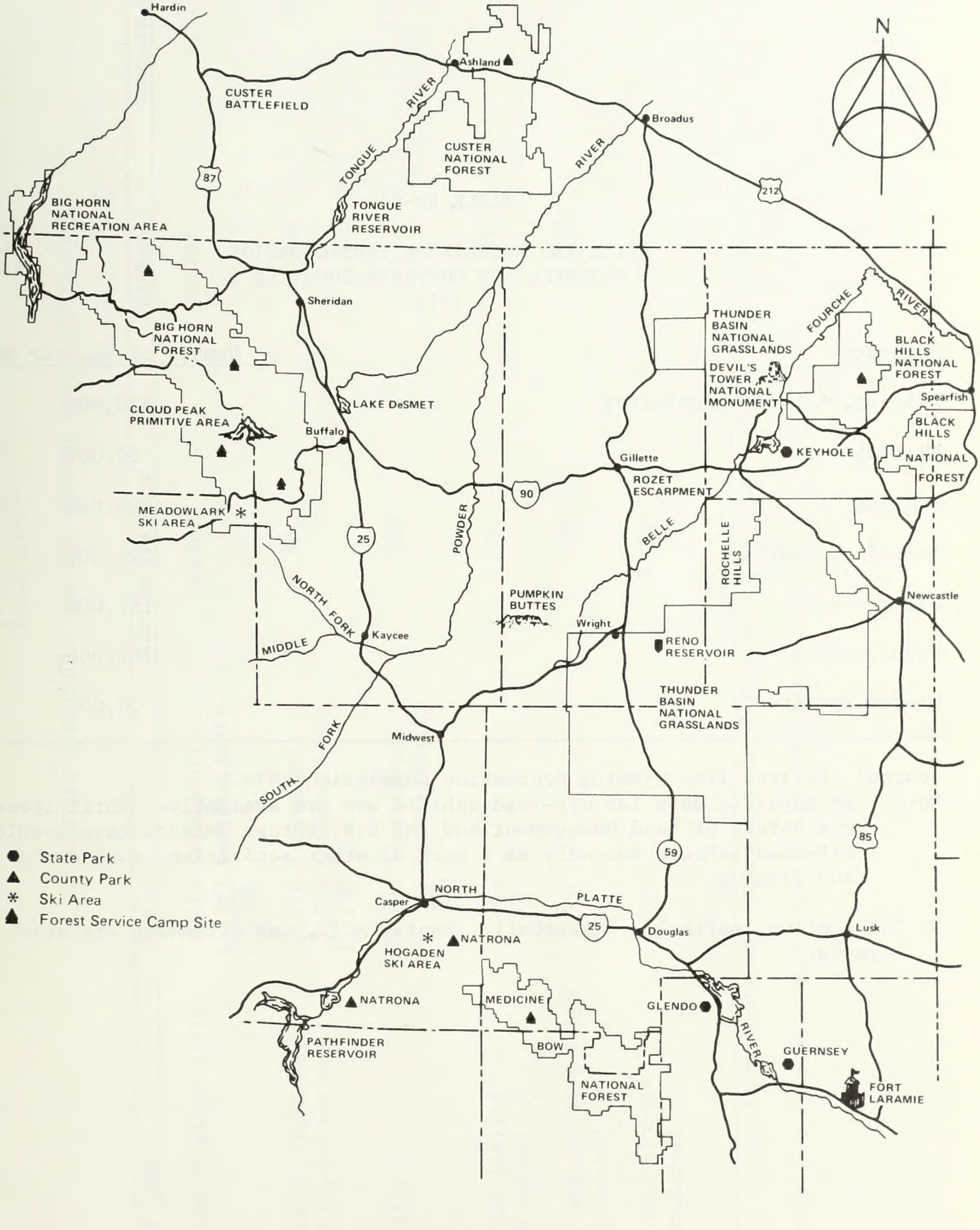


Figure R2-30
REGIONAL RECREATION MAP

TABLE R2-11

ESTIMATED RECREATION PARTICIPATION
CAMPBELL AND CONVERSE COUNTIES
1975

Activity	Number of Visitor Days
Camping, hiking, picnicking	320,000
Fishing	60,000
Hunting	46,000
Municipal sports*	224,000
Sight-seeing	157,000
Water sports	165,000
Winter sports	38,000

Source: Derived from Wyoming Recreation Commission 1975.
Note: No separate data for off-road vehicle use are available. Until recently, the Bureau of Land Management and the U.S. Forest Service have considered off-road vehicle use only as a part of other activities, such as hunting and fishing.

* Ice skating, softball, basketball, tennis, golf, and attending athletic events.

TABLE R2-12

HUNTING STATISTICS FOR THE EASTERN POWDER RIVER BASIN

Type of Game	Hunters	Recreation Days	Harvest	Success Ratio
Pronghorn Antelope (1976)	2,618 (resident) 14,663 (nonresident) 17,281	26,900	16,292	94%
Deer (1976) (Mule Deer and White-tailed Deer)	3,710 (resident) 7,588 (nonresident) 11,298	26,600	8,726	77%
Elk (1976)	106 (resident) 14 (nonresident) 120	300	76	63%
Waterfowl (1975)* (estimated)	614	2,200	3,699	4.8 birds per hunter
Upland Game Birds (975)* (estimated)	556	800	2,692	4.9 birds per hunter
Small Game (1975)* (estimated)	614	1,800	5,452	8.9 animals per hunter

Source: Derived from personal communication, Harry Harjo, Wyoming Game and Fish Department 1976

* Data are for Campbell County and all of Converse County.

occur are primarily privately owned. Stock ponds and larger streams such as the North Platte River provide some fine waterfowl hunting in the late fall and winter.

Fishing

Because of the shortage of streams in the basin and the lack of public access to them or to stock ponds, sport fishing occurs mostly on large reservoirs such as Keyhole, Lake DeSmet, and North Platte River impoundments.

Winter Activities

Downhill skiing at developed commercial facilities within the recreation region is confined to Meadowlark ski area west of Buffalo in the Big Horn Mountains, Hogadon ski area near Casper on Casper Mountain, and Terry Peak northeast of Newcastle in the Black Hills. Areas for cross-country skiing in the mountains surrounding the basin are accessible from all-weather highways. In 1975, skiing by residents of the Eastern Powder River Basin accounted for 9% of the skiing in the recreation region (Wyoming Recreation Commission 1975).

Snowmobiling is a somewhat more significant winter activity. In 1975, snowmobiling by residents of the Eastern Powder River Basin accounted for 22% of the snowmobiling in the recreation region (ibid.). The primary areas for snowmobiling are the Big Horn Mountains, Black Hills, and Laramie Range, in that order.

Water-based Recreation

Water-based recreation is confined to the large reservoirs in and near the region. Keyhole, Glendo, Guernsey, and Alcova reservoirs offer good boating, water skiing, and swimming opportunities in spring and early summer (Figure R2-31). Drawdowns reduce the water levels and the opportunities for recreation in late summer. Residents of Campbell and Converse counties accounted for 21% of the recreation region's total participation in water-based activities in 1975 (ibid.).

Sight-Seeing/Historical Interest

The Eastern Powder River Basin itself has limited value for sight-seeing with the exception of wildlife viewing. On the periphery of the basin are Devils Tower National Monument (Figure R2-32), Pumpkin Buttes, and the Rozet Escarpment. These features and the red cinder cones and coal beds near Gillette provide evidence of the geologic history of the basin.

Visitor interpretive sites have been developed by federal, state, and local agencies and groups, describing the history of the Oregon and Bozeman trails. Those listed on the National Register of Historic Places include Fort Laramie, Fort Fetterman, Fort Phil Kearny, and the Sheridan Inn.

Significant archeological sites, such as the "Medicine Wheel"in the Big Horn Mountains, exist in the recreation region, but most sites are either inaccessible or unprotected from vandalism.

Camping/Picnicking

Except for municipal facilities, developed recreation sites within the Eastern Powder River Basin are minimal. Pumpkin Buttes in southwestern Campbell County is an undeveloped area used by local residents for hiking and picnicking. Most camping and picnicking is undertaken in the cooler mountains surrounding the basin or at major recreation areas, such as Devils Tower National Monument, or Keyhole, Glendo, or Guernsey State Park (Figures R2-33,34, and 35).

Collecting

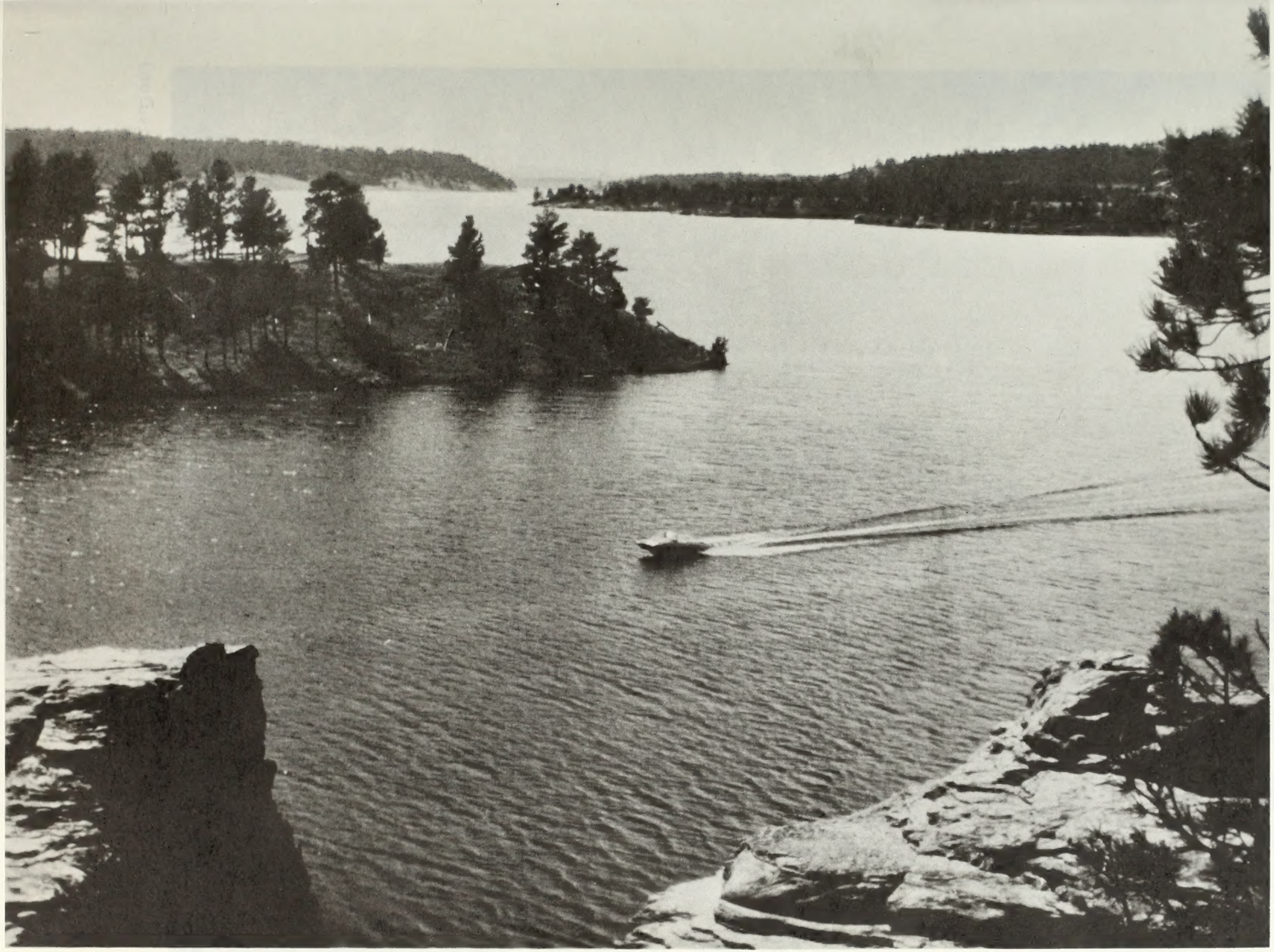
Gem and mineral collecting is popular all across the Eastern Powder River Basin, Black Hills, and Big Horn Mountains, although the value of most minerals is insignificant. One exception is Tepee Canyon agate, a gem of nationwide reknown, from Tepee Canyon, 21 miles east of Newcastle. Petrified wood is also found throughout the region.

Off-Road Vehicle Use

Approximately 35% of the people in Gillette own four-wheel drive vehicles, which are used for transportation on local roads and/or off-road vehicle (ORV) recreation. Dirt bikes are owned by 12.5% (University of Wyoming 1976). ORV use may occur in conjunction with hunting, fishing, or sight-seeing, or simply on overland trails and dirt tracks. A major problem already confronting ORV users is the small amount of public land and restricted access to that land in the Eastern Powder River Basin. Consequently, those public lands that are accessible are suffering ORV damage in the form of soil compaction and vegetation destruction. Trespassing on private land is another problem that results. In order to alleviate some ORV user/landowner conflicts near Gillette, the Campbell County Parks and Recreation Department has made application to the Bureau of Land Management (BLM) for a tract of public land near Gillette to develop an ORV/motorcycle area.

Snowmobiling is a winter ORV activity. (See Winter Activities, above.)

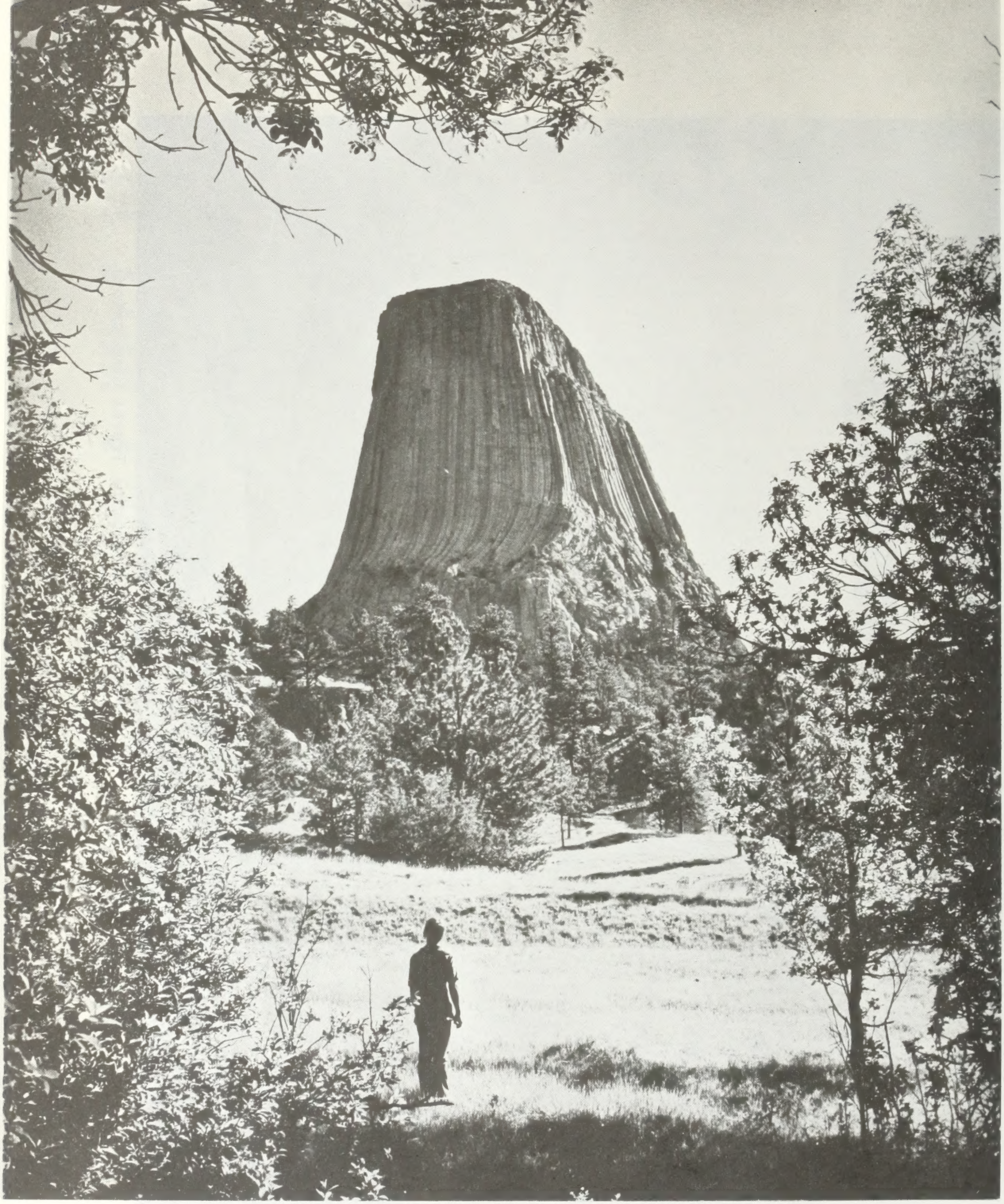
Wilderness Values



(Photo courtesy of Wyoming Travel Commission)

FIGURE R2-31

KEYHOLE RESERVOIR



(Photo courtesy of Wyoming Travel Commission)

FIGURE R2-32

DEVILS TOWER

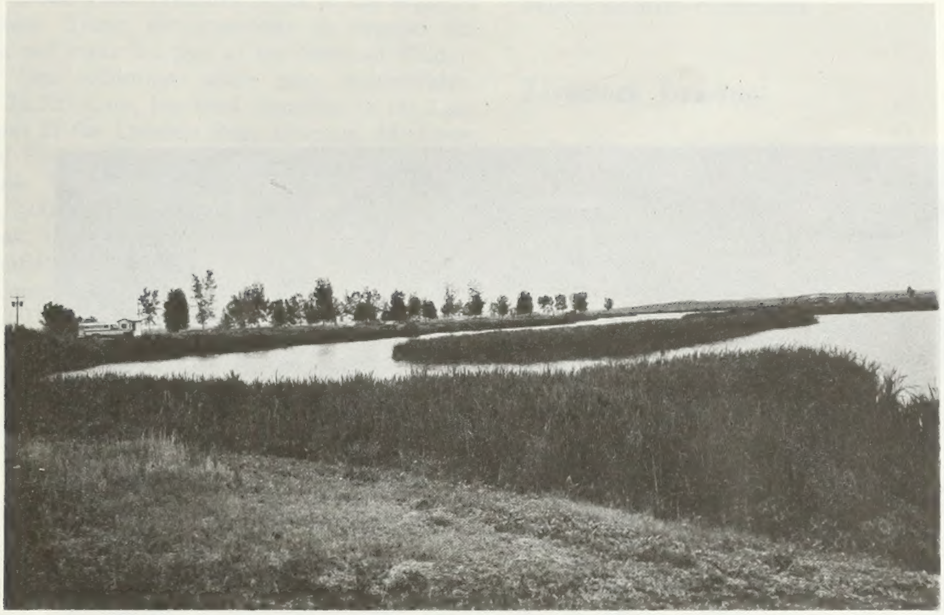


FIGURE R2-33

GILLETTE FISHING LAKE

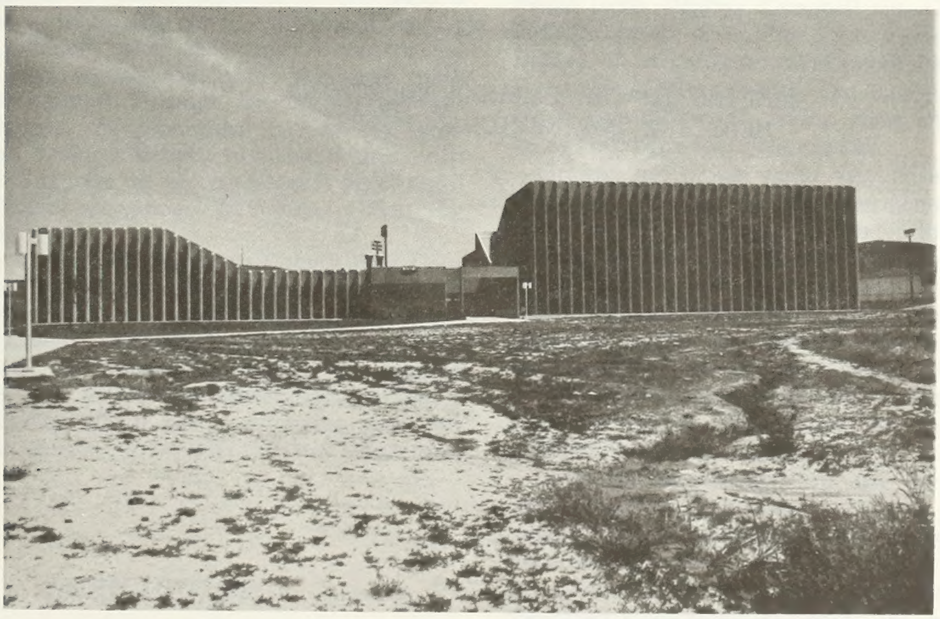


FIGURE R2-34

DOUGLAS COMMUNITY RECREATION CENTER

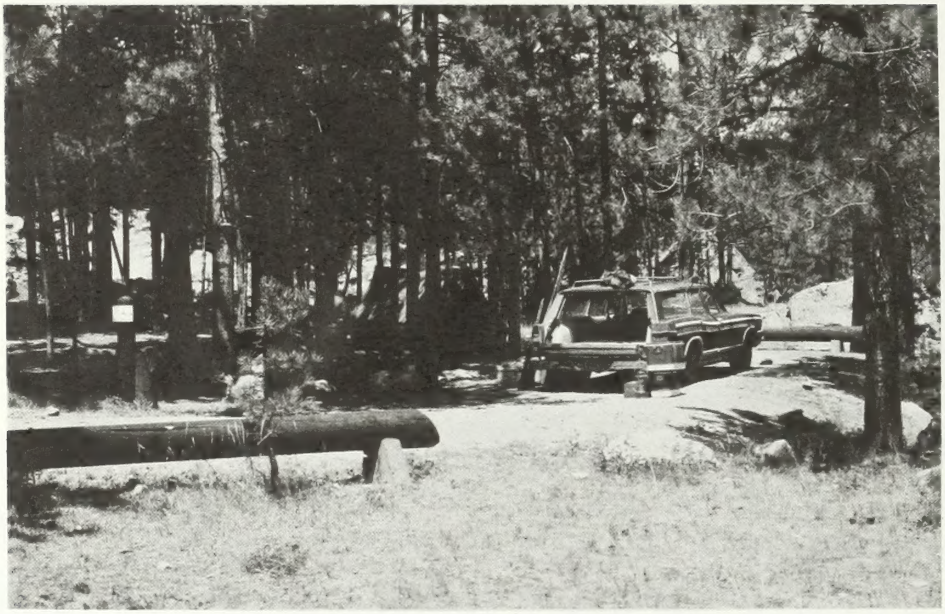


FIGURE R2-35

CAMPING IN THE LARAMIE MOUNTAINS
MEDICINE BOW NATIONAL FOREST

The only existing primitive area in the recreation region is the Cloud Peak Primitive Area in the Bighorn National Forest. There are proposals to expand the primitive area and make it a part of the National Wilderness System. One wilderness study area, Ashenfelder, consisting of 26,500 acres, has been identified in the Laramie Mountains of the Laramie Peak Division, Medicine Bow National Forest. There are also four roadless areas in the Laramie Mountains: Deer Creek, 14,500 acres; Buffalo Peak, 8,000 acres; LaBonte Canyon, 23,200 acres; and Eagle Peak, 12,000 acres.

BLM has initiated a wilderness study of public lands it manages in Campbell and Converse counties to comply with Section 603 of the Federal Land Policy and Management Act of 1976. It is unlikely that any land eligible for wilderness designation will be identified.

The Fortification Creek area on the Campbell-Johnson county line has been identified as a potential natural area.

Municipal Recreation

The communities of Gillette, Douglas, and Wright are experiencing increasing pressure for close-to-home recreation. In Campbell County, the city of Gillette and the Campbell County Parks and Recreation Department provide parks, recreation facilities, and recreation programs for all ages. The county department is supported by a county-wide mill levy. The new community of Wright, which is being developed by Atlantic Richfield Company (ARCO), has a softball field for residents, and ARCO has announced plans for development of additional recreation facilities.

In 1974, Gillette and Campbell County were considered up to national recreation standards in most aspects (Campbell County Recreation Study 1974). However, the most pressing problem facing the county recreation department has been the acquisition of satisfactory park land as Gillette expands. Through recently enacted subdivision regulations, the department is receiving dedicated park land which is helping to alleviate this shortage. Table R2-13 reports the perceived needs (as of April 1976) for additional recreational facilities in Gillette by order of priority.

In Converse County, the Converse County Park Commission operates the county's two parks in the southern part of the county. The commission has no plans for expansion of the county park system at this time. In Douglas and Glenrock, the recreation programs are operated in conjunction with the school district. Douglas has a new indoor facility which has a swimming pool and handball courts; the city of Douglas operates a system of parks.

AGRICULTURE

Throughout its settled history, the region's dominant economic activity has been dryland ranching, despite recent active mineral developments. Agricultural exports, mainly beef, presently constitute the largest nonenergy export industry of the area.

Livestock Grazing

Production of range beef cattle and sheep is the predominant land use within the region. An estimated 94% of the land within Campbell and Converse counties is used as rangeland. The 1969 Census of Agriculture (U.S. Department of Commerce) indicates that 793 ranch operations are present within the two-county area. The average ranch is 7,276 acres and carries approximately 262 animal units (one cow, one horse, or five mature sheep constitute one animal unit). Most ranches are reasonably well contained in contiguous ownership patterns. A few ranches in western Campbell County move sheep and cattle from winter range to summer range holdings in the southern Big Horn Mountains. Based on federal grazing lease statistics, 59% of the ranches are cattle operations, 14% are sheep operations, 25% both sheep and cattle, and the remaining 2% are ranches and farms with dairy cattle, horse, or buffalo operations. According to the Wyoming Crop and Livestock Reporting Service (U.S. Department of Agriculture 1972), there are 167,200 cattle and calves and 240,200 sheep and lambs in Campbell and Converse counties. Many livestock operations have been shifting from sheep to cattle in recent years for economic reasons. Other classes of livestock contribute little to total production within the region.

Many of the ranch operations rely on leased lands to maintain size of operations at a desired economic level. Federal and state lands are the major component of leased lands. (Within Campbell and Converse counties, land ownership is distributed as follows: private, 79%; Bureau of Land Management public lands, 7%; national forest lands, 6%; and state and local lands, 8%.) Some ranch consolidation is taking place and industrial concerns have been acquiring ranches.

Grazing use of the range may be either seasonal or yearlong, depending on the management system established on the specific tract. Winter forage is a critical limiting factor to the livestock industry in the region. Sheep ranchers rely on native range to winter the livestock. During severe winters they supplement feed with native hay and/or purchased protein concentrates. Cattle are generally wintered near ranch headquarters and are maintained on locally grown hay as well as protein supplements. During the summer months, livestock are moved to summer rangelands.

Livestock distribution and use of available range forage is affected by water availability. Livestock water impoundments and wells are important since little natural water exists in many parts of the region. Streams are limited and most are intermittent. Control of livestock on the range is primarily by fencing for cattle and by both herding and fencing for sheep. Other facilities necessary for livestock management on the range include corrals, stock driveways, access roads, and ranch facilities.

TABLE R2-13

PERCEIVED NEED FOR RECREATIONAL FACILITIES
EXPRESSED BY GILLETTE RESIDENTS

Facility	Amount of Need		
	Very Great Or Great	Moderate	Low or None
Parks	80.7%	12.6%	6.7%
Playgrounds	78.2%	16.8%	5.0%
Youth Center*	75.3%	16.4%	8.4%
Senior Citizen's Center*	69.7%	20.2%	10.1%
Ice Skating Rink	62.1%	22.1%	15.8%
Roller Skating Rink	59.6%	24.2%	16.3%
Gymnasium	58.7%	23.8%	17.5%
Ball Fields	52.4%	30.2%	17.4%
Indoor Swimming Pool	50.4%	16.2%	33.4%
Bowling Center	49.8%	26.6%	23.6%
Tennis Courts	49.2%	31.1%	19.7%
Handball Courts	36.4%	34.3%	29.3%
Motorcycle Track	33.7%	30.4%	35.9%

Source: University of Wyoming 1976.

* Since this study was completed, the Campbell County Parks and Recreation Department has opened both a youth center and senior citizen's center.

Farming

The Eastern Powder River Basin is not noted for extensive farming activities. Farming occurs on 2.5% of the land area in Campbell and Converse counties. Hay and forage are the major crops raised within the region because of livestock industry needs and prevailing climatic conditions. Most farming is conducted by livestock operations, and hay is used locally. Hay production is not sufficient to provide total winter forage requirements. Most operations rely on native range to winter livestock. (In many cases, hay is saved and used only during critical winter periods as prices in the market reach premium levels.)

Most of the hay is produced on irrigated meadows along the North Platte River and, to a lesser extent, on dryland farms in Campbell County. Both alfalfa and grass hay are grown, but alfalfa is predominant on the irrigated meadows.

Irrigated farmlands are primarily limited to Converse County. The number of acres under irrigated crop production has been rising gradually over the years but is limited by the availability of water. Projected water requirements for irrigation (10,000 acre-feet per year) show no change for the period 1978 through 1990 (Table R2-8). Adequate water would be available for minimal increases in irrigation, based on recharge rates of the water table (see Water Resources, Chapter 4).

Dryland farming is the primary farming practice in Campbell County due to lack of irrigation water. The most successful dryland farm areas in the region are located in northern Campbell County, from Gillette northward, where annual precipitation is 14 to 17 inches. Dryland farming south of Gillette has proven to be marginal to submarginal over an extended time period.

Dryland farming acreages change from year to year, reflecting market fluctuations and weather conditions. The last four decades have shown wide variability in acreages, crop yields, and success. During Wyoming's early homesteading era from 1920 to 1930, large acreages of semiarid lands were being tilled. The final chapter of homestead development was written in dust storms and ruined lands when droughts occurred on the area. Many of these lands were reacquired by the federal government under the National Industrial Recovery Act of 1933, Emergency Relief Act of 1935, and Bankhead-Jones Act of 1937. Most of these lands are currently included in the Thunder Basin National Grasslands.

Total dryland cropland decreased over the years as submarginal lands were retired from cultivation, because the land proved to be more valuable and suitable for livestock grazing. During the past few years, some of these lands have again been placed into crop production in response to government farm programs and rises in grain prices.

Agricultural lands must meet certain requirements of the Surface Mining Control and Reclamation Act (SMCRA) to be considered prime farmland. These requirements include such factors as proper soils, a history of cropping, land slopes, and irrigation systems in areas with less than 14 inches of annual precipitation. Prime farmland is probably present in the region, but is expected to be a minor component of the agricultural lands. No formal designation of prime farmland has yet occurred in the region. Agricultural lands on each proposed mine site will be analyzed on a site-specific basis to determine if they meet the SMCRA requirements for prime farmland.

FOREST RESOURCES

Ponderosa pine is the only commercial timber species existing in the Eastern Powder River Basin of Wyoming. It is confined primarily to ridges, escarpments, plateaus, benches, and rolling hills which rise above the surrounding plains. It occurs in small scattered patches. On the poorer sites it is found in association with Rocky Mountain juniper.

Generally, the trees are of poor quality: they are short and limby. Sawtimber-size trees are limited and scattered sporadically throughout the stands. Stocking (the number of trees per acre) is rated as poor.

History of the timber areas indicates limited use in the past. Use consisted primarily of products needed for homesteads, ranch accessories, and fuel. With the exception of minor products such as boughs, cones, wildings, posts, and poles, there is little present demand for forest products.

In the context of the surrounding plains area, the ponderosa pine forests are considered more important for wildlife habitat and recreation than for wood fiber.

MINERAL RESOURCES

Coal development, both present and proposed, uranium mining projects and mills, and selected oil and gas fields are shown on the regional activity map (Map 1, Appendix A). Energy resources are also shown on Map 10, Appendix A.

Coal

The Eastern Powder River Basin lies within the Powder River Coal Basin and includes all or part of nine coal fields as defined by the U.S. Geological Survey (Figure R2-36).

Minable (under less than 3,000 feet of overburden) coal deposits underlie more than 90% of the region. The coal is all of subbituminous rank except for a small deposit of lignite in northern Campbell County (Figure R2-36). According to Breckenridge and others (1974), 50.4% of Wyoming's remaining minable coal resources and 84% of its known strippable (under less than 200 feet of overburden) coals are in Campbell County. Known strippable coal deposits and related energy development in the Powder River Coal Basin are shown in Figure R2-37. Total identified original minable coal resources for the region are 73,187.81 million tons (Glass, 1976). Of this, 69,033.84 million tons are in Campbell County and

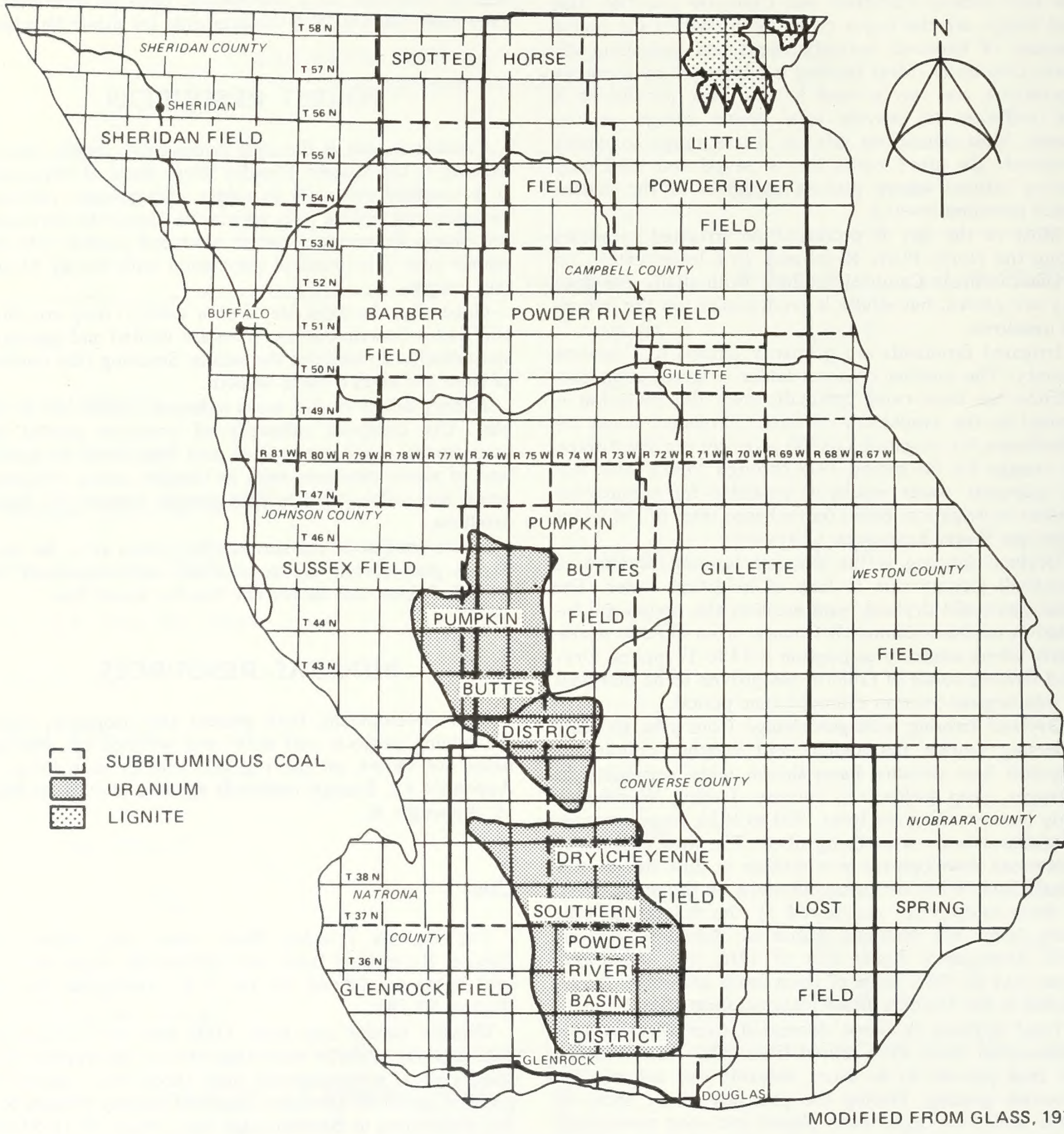


Figure R2-36

COAL FIELDS AND URANIUM DISTRICTS IN THE POWDER RIVER BASIN

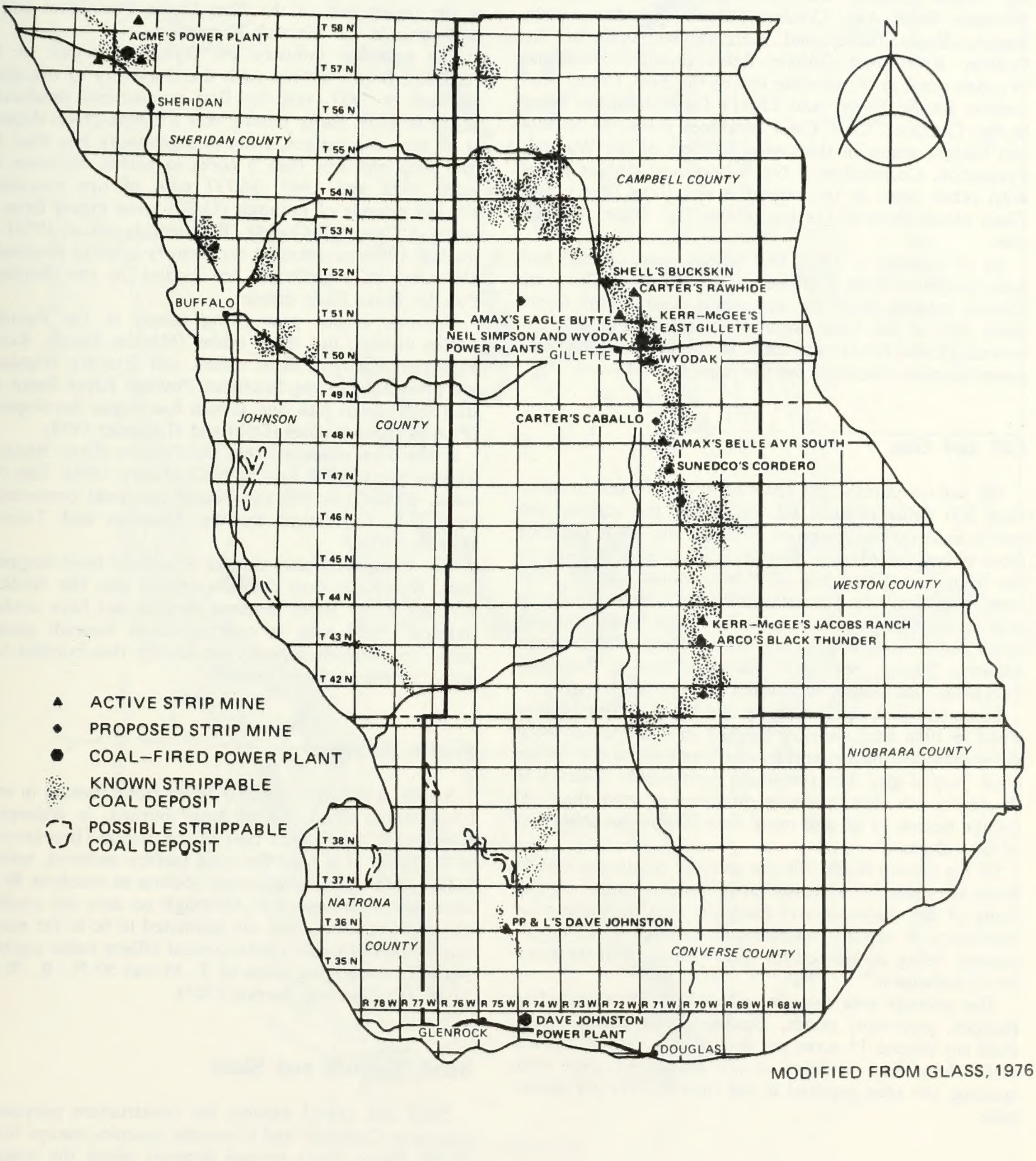


Figure R2-37

COAL RESOURCES AND DEVELOPMENT IN THE POWDER RIVER BASIN

4,153.97 are in Converse County. Available data on coal resources by county and field are shown on Table R2-14.

Coal is presently being produced from nine mines in the region (Figure R2-37). Eight mines (Rawhide, Wyodak, Belle Ayr, Cordero, Black Thunder, Jacobs Ranch, Eagle Butte, and Kerr-McGee 016) in the Powder River and Gillette fields produce from the Wyodak seam at or near the top of the Fort Union Formation. Pacific Power and Light's Dave Johnston Mine in the Glenrock Coal Field produces from the School and Badger seams in the lower 200 feet of the Wasatch Formation. Correlation of the School and Badger seams with other coals in the region is not clear (ibid.), and Glass places them in the top of the Fort Union Formation.

As of January 1, 1975, 19.2 million tons of coal had been produced from Campbell and 25.18 from Converse County totaling 44.38 for the region (ibid.). This represents .2% of the total original estimated strippable resources (Table R2-14) and .06% of the total original estimated minable resources for the region.

Oil and Gas

Oil and/or natural gas have been discovered in more than 200 fields (Figure R2-38) within the region, and active exploration continues. Most of the fields produce from either the Muddy Sandstone of Cretaceous age or the Minnelusa Formation of Pennsylvanian age or from both. The Cloverly Formation of early Cretaceous age is also an important producing horizon and lesser amounts of oil and/or natural gas come from Sundance, Morrison, Mowry, Turner, Niobrara, Shannon, Sussex, Parkman, Ferguson, and Teapot sandstones (Figure R2-7).

From the first significant oil discovery at Big Muddy Field in 1916 until January 1, 1973, production has been more than 400 million barrels of oil and about 400 billion cubic feet of gas. The remaining recoverable reserves in the region are conservatively estimated at more than 200 million barrels of oil and more than 500 billion cubic feet of natural gas.

Of the known fields, 166 are actively producing and 44 fields are classified as temporarily nonproductive. A majority of the nonproductive fields are shut in, waiting for secondary or tertiary recovery procedures to be implemented, being considered for reactivation, or in the process of activation.

The average area used by oil well facilities including pumper, separator, ponds, pipelines, and access roads, does not exceed 15 acres per square mile. Where several wells share land facilities or are developed with wide spacing, the area required is less than 5 acres per square mile.

Uranium

Ore-grade uranium occurs in two mining districts in the region: the Pumpkin Buttes district in Campbell, Converse, and Johnson Counties, and the Southern Powder River Basin district in Converse County. Host rocks for uranium ore in the Pumpkin Buttes district are sandstones in the Wasatch Formation. In the Southern Powder River Basin district the ore occurs in sandstone in the upper part of the Fort Union Formation and in sandstones in the Wasatch Formation.

The uranium industry of Wyoming began in the Pumpkin Buttes district with the discovery of ore-grade uranium in 1951, and the first commercial production began in 1953. Early mining was for high-grade deposits at or near the surface, from pits generally less than 100 feet deep and less than 5 acres in extent. Between the years 1953 and 1967, 36,737 tons of ore containing 208,143 pounds of uranium (U_3O_8) were mined from 55 mines in Campbell County (Breckenridge et al. 1974). By the late 1960s accelerated exploratory activity resulted in discovery of significant ore bodies in the Southern Powder River Basin district.

Uranium is not now being mined in the Pumpkin Buttes district, but three mines (Morton Ranch, Rocky Mountain Energy's Bear Creek and Exxon's Highland) are producing in the Southern Powder River Basin district from open pits, and Exxon has begun development of underground mines (Dahl and Hagmaier 1976).

It has been estimated that the Powder River Basin resources are 185,000 tons of U_3O_8 (Curry 1976). The 1978 value of U_3O_8 is $40 per pound (personal communication, U.S. Geological Survey, Uranium and Thorium Branch 1978).

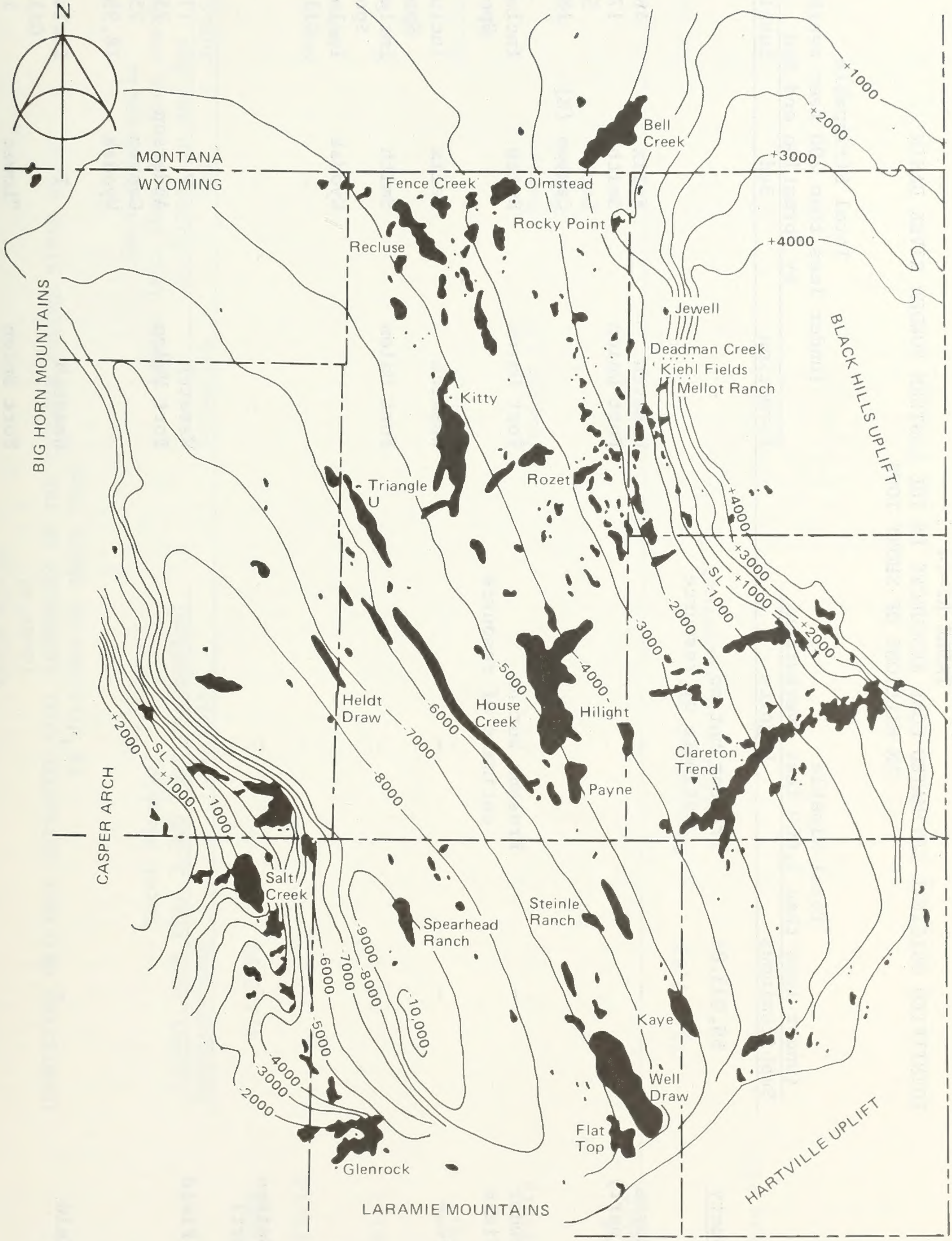
The Pumpkin Buttes district is west of most strippable coal. Strippable coal deposits extend into the Southern Powder River Basin uranium district and here uranium deposits could exist in overburden or beneath minable coal. No uranium deposits are known that conflict with active or planned coal mines.

Scoria (Clinker)

Scoria, a reddish baked or fused stone formed in overlying strata when a coal seam burned, is widespread throughout the eastern part of the region (Breckenridge et al. 1974). It is used for road surface material, railroad ballast, and construction stone. Scoria as much as 50 feet thick has been reported. Although no data are available on actual reserves, they are estimated to be in the numerous billions of cubic yards, several billion cubic yards reportedly underlying parts of T. 49 and 50 N., R. 70 and 71 W. (Dobbin and Barnett 1927).

Sand, Gravel, and Shale

Sand and gravel suitable for construction purposes is scarce in Campbell and Converse counties except for the North Platte River terrace deposits along the southern boundary of the region. Here the Wyoming Highway Department has identified several deposits containing not less than 25,000 cubic yards of sand and gravel. Scattered local deposits as much as 10 feet thick with pebbles up to 2 inches in diameter are found along some of the



(NAMES SHOWN ON LARGER FIELDS ONLY)

MODIFIED FROM ARRO, 1976

Figure R2-38

DISTRIBUTION OF OIL AND GAS FIELDS IN THE EASTERN POWDER RIVER BASIN

TABLE R2-14
IDENTIFIED ORIGINAL ESTIMATED COAL RESOURCES IN THE EASTERN POWDER RIVER BASIN
IN MILLIONS OF SHORT TONS

	Total Minable (under less than 3,000 feet overburden)		Total Strippable (under less than 200 feet overburden) by Formation and Bed		
	Subbituminous	Lignite	Formation	Bed	Subbituminous
Campbell County	69,033.84	Present but no estimate of resource	-	-	-
Spotted Horse Field (part)	-	-	Wasatch	Felix	480.7*
			Fort Union	Smith	178.0*
				Local	58.3*
				Canyon (E)	184.9*
Little Powder River Field	-	Present but no estimate of resource	Fort Union	Smith	Included in Spotted Horse
Powder River Field	-	-	Wasatch	Felix	Included in Spotted Horse
			Fort Union	Smith	Included in Spotted Horse
				Wyodak	Included in Gillette
Pumpkin Buttes Field (part)	-	-			-
Gillette Field	-	-	Wasatch	F	179.5*
			Fort Union	Anderson	250.0*
				Canyon	250.0*
				Wyodak	18,998.8**
Sussex Field (part)	-	-	Wasatch	F	Included in Gillette
			Fort Union	"Lower"	13.6*

TABLE R2-14
(cont'd)
IDENTIFIED ORIGINAL ESTIMATED COAL RESOURCES IN THE EASTERN POWDER RIVER BASIN
IN MILLIONS OF SHORT TONS

	Total Minable (under less than 3,000 feet overburden)		Total Strippable (under less than 200 feet overburden) by Formation and Bed		
	Subbituminous	Lignite	Formation	Bed	Subbituminous
Converse County	4,153.97	-	-	-	-
Gillette Field (part)	-	-	-	-	See Gillette above
Sussex Field (part)	-	-	-	-	See Sussex above
Dry Cheyenne Field	-	-	Wasatch	F	Included in Gillette
Glenrock Field (part)	-	-	Wasatch (?)	Badger School	9.5 114.7
Lost Spring Field (part)	-	-			-
TOTAL	73,187.81	Present but no estimate of resources			20,708.00

Source: Glass 1976

major streams within the basin. Extensive deposits of windblown sand occur in the southwest corner of the region.

Shale for local use as road surface material is quarried from the Potter shale pit about 3 miles from Gillette.

TRANSPORTATION NETWORKS

Railroads

This section reviews changes in the amount and composition of rail freight transported on the Burlington Northern Railroad in recent years. These changes have affected Eastern Powder River Basin communities situated along the railroad, as well as communities beyond the boundaries of the region. The communities discussed here were selected for analysis on the basis of (1) location along major coal train routes, (2) degree of impacts, and (3) population size. Smaller communities (those under 1,000 population) are not analyzed explicitly, but the problems they experience are similar in nature.

Coal and Other Freight Train Traffic

Burlington Northern (BN) owns the only main line track available for transporting coal from the Eastern Powder River Basin. The estimated rail traffic capacity of this main line varies from 40 to 65 trains per day. Current traffic levels shown in Table R2-15 represent about 40% to 60% of available capacity.

Table R2-16 summarizes commodity statistics for coal and noncoal freight tonnage originating in Wyoming on the BN main line. (Freight traffic originating outside Wyoming and carried through the state is not included in these statistics.) During the time period shown, total freight traffic increased 364%, while coal traffic increased by 915%. Almost all of the increase in coal freight can be attributed to coal from the Eastern Powder River Basin. Noncoal tonnage remained fairly level at about 2 million tons throughout the time period shown.

Estimated 1978 coal production and unit train traffic for the Eastern Powder River Basin are shown in Table R2-17. Current coal traffic data reported by the BN are shown in Table R2-15. Coal trains from the Eastern Powder River Basin in Table R2-15 appear in the change in coal traffic between Gillette, Wyoming and Edgemont, South Dakota. Based on BN projections, approximately 77% of the coal trains traveling towards South Dakota and Nebraska currently originate in the Eastern Powder River Basin. The remaining 23% come from coal mines in Sheridan County, particularly the Big Horn Mine, and from the Decker Mine in the state of Montana. All coal transported out of the Eastern Powder River Basin is now moving eastward towards market destinations shown in Table R2-17.

Community Effects

Effects of coal train traffic are already felt not only in the immediate vicinity of the mine, but also along the railroad line where train traffic has increased. Communities along the BN route feel the effects of rail traffic in a variety of ways. Traffic delays occur at railroad-highway crossings, creating an inconvenience to local residents. Essential services such as ambulance, fire, and police are also detained at railroad crossings.

The magnitude of these effects depends on the frequency of exposure, the length of the train, and the train speed (U.S. Department of Transportation 1978). Unit trains, which average about a mile in length, take 3 minutes to pass a particular point at 20 miles per hour. If the speed slows to 5 miles per hour, as it sometimes does near switchyards, it takes 12 minutes for the same length train to pass. The effect of speed at crossings is apparent from the following example: given a traffic flow of 25 unit coal trains per day, a railroad crossing is impassable for an hour and 15 minutes per day at 20 miles per hour and for 5 hours per day at 5 miles per hour.

Air pollution from increased rail traffic is not yet considered a problem in the state of Wyoming, since breezes rapidly dissipate exhaust fumes and coal dust (personal communication, Chuck Collins, Wyoming Department of Environmental Quality 1978).

Even though the intensity of noise levels does not increase as additional train traffic occurs, the frequency of exposure causes more irritation to local residents, particularly if the railroad tracks are located near residential areas.

The BN track and principal communities affected by rail traffic locally in northeastern Wyoming are shown in Figure R2-39. Similar information is presented in Figure R2-40 for out-of-state communities affected by the movement of the region's coal. Since coal traffic on the BN branches out to various market areas in Lincoln, that community is the most easterly point reviewed.

The major effects cited by local officials are summarized below.

Sheridan. Five coal trains and four regular freight trains pass through Sheridan daily. Currently, an at-grade crossing at Fifth Street is the most serious problem (*The Sheridan Press*, February 9, 1978). Automobiles and pedestrians are often delayed for 10 minutes at a time. The location of a switchyard near the center of Sheridan contributes to traffic delays, because trains reduce their speed as they approach the switchyard. This lengthens the time it takes to pass by a crossing. A railroad crossing study conducted by the State Highway Department in 1977 identified the Fifth Street crossing as needing a grade separation, but funds have not yet been appropriated for this (personal communication, John Hollingsworth, Sheridan County Planner 1978).

Gillette. Although coal and regular freight trains currently amount to only eight per day, serious problems were reported. Automobile and pedestrian traffic is often blocked downtown while train crews change in Gillette.

Another result of the train traffic is the isolation of the north section of Gillette from the rest of the community whenever a train passes by. Emergency services have

TABLE R2-15

ESTIMATED AVERAGE DAILY TRAFFIC IN REGION
-1978-

	Eastbound Trains		Westbound Trains		
	Regular Freight	Coal*	Regular Freight	Coal*	Total
Sheridan to Gillette, Wyoming	2	2.5	2	2.5	9.0
Gillette to Donkey Creek	2	3.25	2	3.25	10.5
Donkey Creek to Edgemont, S.D.	3	10.67	3	10.67	27.34
Edgemont to Alliance, Nebraska	2	10.67	2	10.67	25.34
Alliance to Grand Island**	2	7.11	2	7.11	18.22
Grand Island to Lincoln	6	7.11	5	7.11	25.22
Alliance to Northport**	3	3.56	3	3.56	13.12

Source: Personal communication Gerald Davies, Assistant Vice President of Coal, Burlington Northern Inc., April 24, 1978.

* Increase due to Eastern Powder River Basin coal amounts to 8.2 trains eastbound and 8.2 trains westbound.
** Traffic moves both south and east on Burlington Northern tracks lines out of Alliance, Nebraska.

TABLE R2-16

REVENUE FREIGHT ORIGINATING ON BURLINGTON NORTHERN RAILROAD
(1973-1975-1977)

Year	Principal Commodities		Number of Tons (2,000 pounds)	Percent of Total
1977	Coal		17,370,428	88
	Noncoal:		2,266,530	12
	Stone, Clay, and Glass, Products	1,177,887		
	Petroleum and Coal Products	406,822		
	Nonmetallic Minerals, except Fuels	290,717		
	Farm Products	128,533		
	Other	262,571		
	Subtotal:	2,266,530		
	Total:		19,636,958	100
1975	Coal		4,923,208	69
	Noncoal:		2,219,021	31
	Stone, Clay, and Glass Products	1,175,055		
	Petroleum and Coal Products	356,536		
	Nonmetallic Minerals, except Fuels	300,933		
	Farm Products	180,802		
	Other	205,695		
	Subtotal:	2,291,021		
	Total:		7,142,229	100
1973	Coal		1,711,452	40
	Noncoal:		2,519,087	60
	Stone, Clay, and Glass Products	1,186,343		
	Petroleum and Coal Products	446,333		
	Nonmetallic Minerals, except Fuels	255,359		
	Farm Products	391,457		
	Other	239,595		
	Subtotal:	2,519,087		
	Total:		4,230,539	100

Source: Public Service Commission, Cheyenne, Wyoming, April 1978.

TABLE R2-17

ESTIMATED PRODUCTION LEVELS OF COAL FROM EXISTING MINES IN 1978

Existing Mines	Number of Unit Trains for 1978*	Market Destination**
Wyodak	0	Mine Mouth (Wyodak)
Dave Johnston	0	Mine Mouth (Dave Johnston Power Plant)
Belle Ayr	1,650	Colorado, Texas, Indiana, Kansas, Missouri, Iowa
Cordero	500	Texas
Rawhide	300	Indiana, Nebraska
Black Thunder	350	Nebraska, Oklahoma, Texas
Jacobs Ranch	200	Arkansas, Louisiana, Oklahoma
Eagle Butte	120	Unknown
Kerr-McGee #16***	---	Unknown
	3,120	

Daily average = 3,120 trains per year ÷ 365 days = 8.5 trains per day eastbound (loaded)
8.5 trains per day westbound (empty)

Source: Based on conversations with Gary Glass, Wyoming Geological Survey, Dale Hoffman, Department of Economic Planning and Development, Wyoming State Government, and Don Warfield, Community Relations Representative, AMAX Coa Co., April 1978.

* The length of a unit coal train currently varies between 80 and 90 cars, however, the available train length is expected to increase to 100 to 110 coal cars. Current and projected traffic estimates assume an average train length of 100 cars with five diesel units.

** Based on contracts reported in Western Oil Reporter, February 1978.

*** Not operational in April 1978. Production may begin later this year.

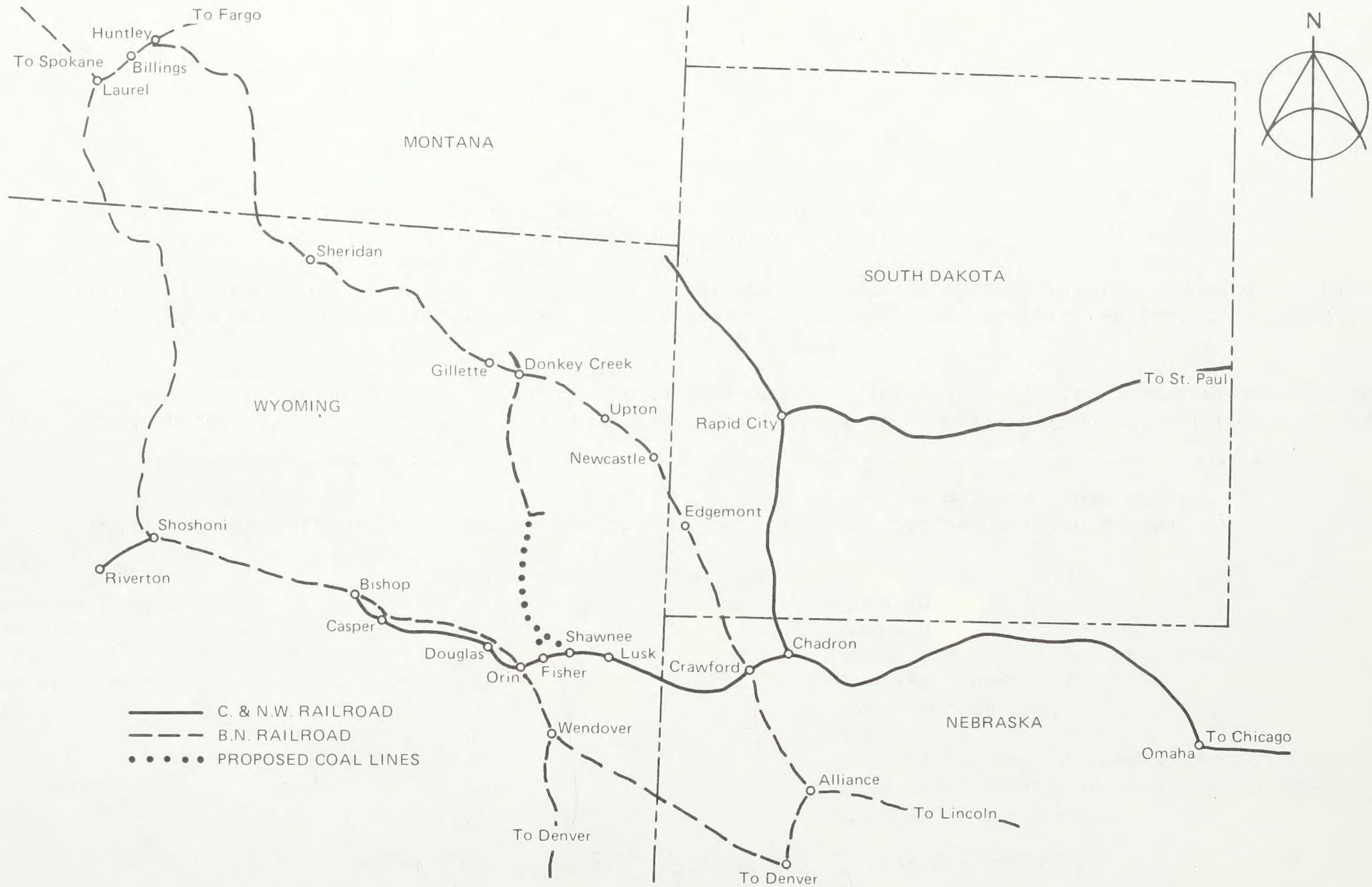


Figure R2-39
RAILROAD LINES SERVING EASTERN POWDER RIVER BASIN

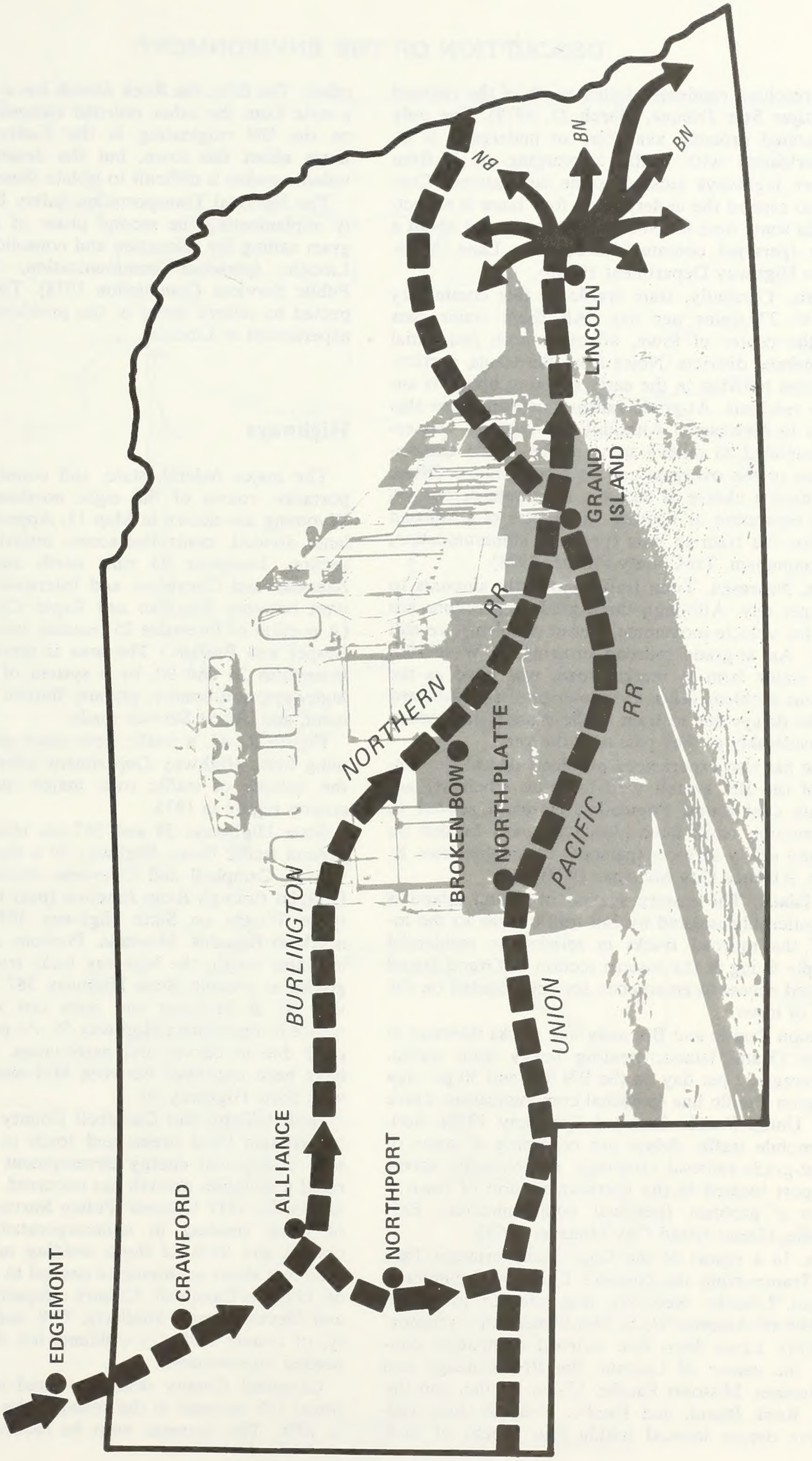


Figure R2-40
CURRENT ROUTING OF POWDER RIVER BASIN COAL ON THE BURLINGTON NORTHERN THROUGH SOUTH DAKOTA AND NEBRASKA

difficulty reaching residents located north of the railroad tracks (*Casper* Star *Tribune*, March 27, 1978). The only grade-separated crossing available, an underpass, is already overloaded with traffic converging on it from three other highways lacking grade separations. Construction to expand the underpass to four lanes is expected to begin some time in 1980 and be completed about a year later (personal communication, John Lane, Wyoming State Highway Department 1978).

Newcastle. Currently, train traffic in this community amounts to 27 trains per day. All these trains pass through the center of town, affecting both residential and commercial districts. Noise from the trains, particularly whistles blowing in the early morning hours, is annoying to residents. At-grade railroad crossings are also a problem in Newcastle. Although an overpass was recently completed to relieve some of the traffic congestion, access to the overpass can be inconvenient. Often, residents have a choice of taking a 10-minute detour via the grade separation or waiting 10 minutes at a railroad crossing for the train to pass (personal communication, Abbie Birmingham, Tri-County Planner 1978).

Alliance, Nebraska. Train traffic currently amounts to 25 trains per day. Although three grade separations are available for vehicle movement, transit problems are still occurring. An at-grade railroad crossing at West 10th Street, a major farm to market road, was cited as the most serious problem. Also, the presence of a switchyard adds to the delays due to train traffic since trains reduce speed considerably as they pass near the yard.

Alliance has also experienced problems due to the renovation of the BN switch yard to more efficiently accommodate coal trains. Population increases related to the construction work have placed a heavy burden on housing and utility services (personal communication, R. A. Placek, Alliance City Manager 1978).

Grand Island. The eastern section of Grand Island is already noticeably isolated by rail traffic. Due to the location of the railroad tracks in relation to residential area, people living in the eastern section of Grand Island have limited access to emergency services located on the west side of town.

The Union Pacific and BN main line tracks intersect in downtown Grand Island, creating heavy train traffic. Trains average 22 per day on the BN line and 30 per day on the Union Pacific line (personal communication, Dave Wheeler, Union Pacific Railroad Company 1978). Serious automobile traffic delays are occurring at some of the BN at-grade railroad crossings. Additionally, access to an airport located in the northern section of town is sometimes a problem (personal communication, Earl Ahlschwide, Grand Island City Manager 1978).

Lincoln. In a report of the Coal Transportation Task Force, "Transporting the Nation's Coal—A Preliminary Assessment,"Lincoln, Nebraska was referred to as the "coal chute of America"(U.S. Department of Transportation 1978). Lines from five railroad companies converge in the center of Lincoln: the BN, Chicago and North Western, Missouri Pacific, Union Pacific, and the Chicago, Rock Island, and Pacific. Four of these railroads have depots located within four blocks of each other. The fifth, the Rock Island, has a train depot about a mile from the other railroad stations. Unit coal trains on the BN originating in the Eastern Powder River Basin affect this town, but the density of other train volume makes it difficult to isolate these effects.

The National Transportation Safety District is currently implementing the second phase of a four-phase program calling for relocation and consolidation of tracks in Lincoln (personal communication, Lester Fletcher, Public Services Commission 1978). This program is expected to relieve many of the problems currently being experienced in Lincoln.

Highways

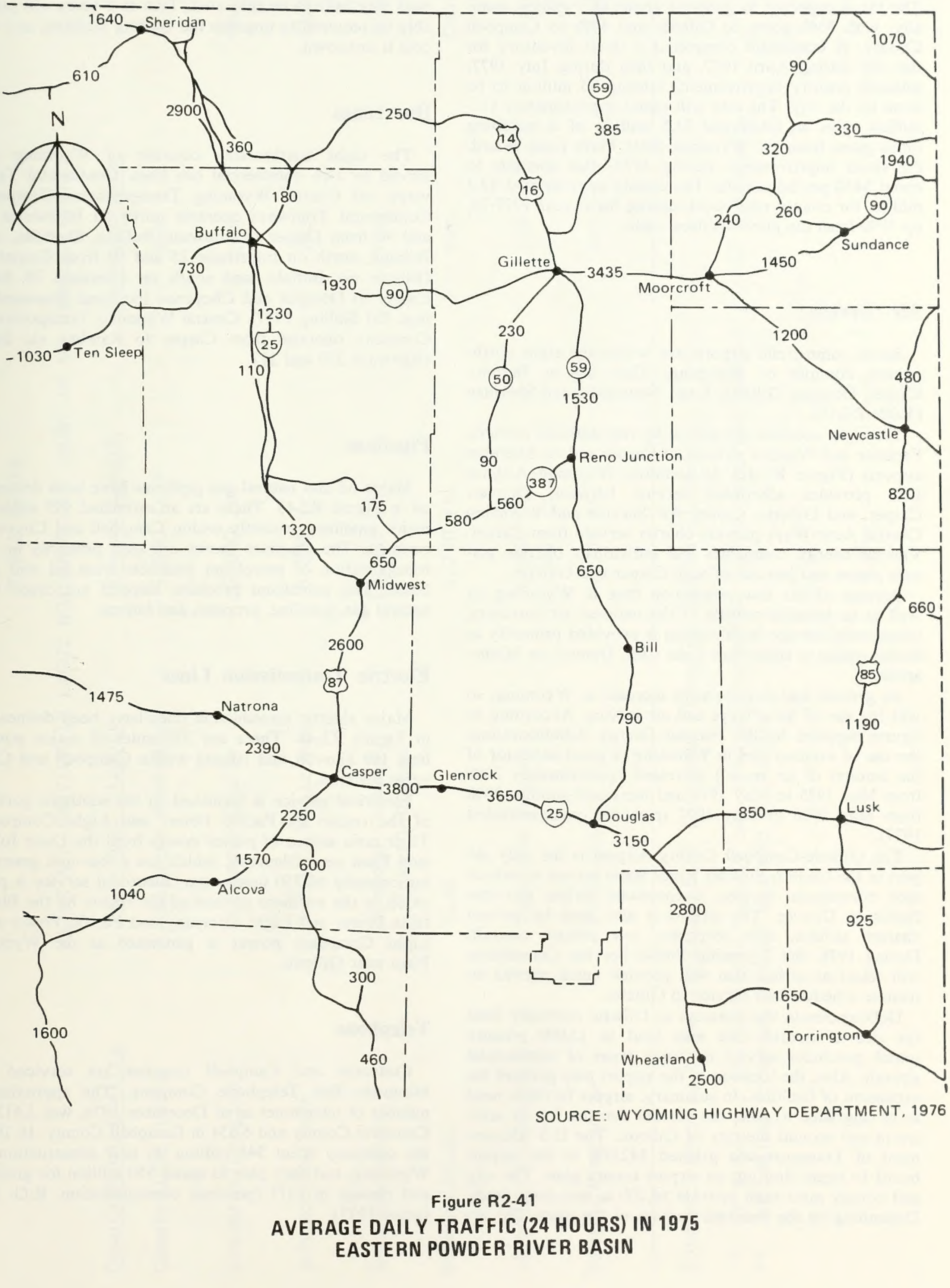
The major federal, state, and county highway transportation routes of the eight northeastern counties of Wyoming are shown in Map 11, Appendix A. Two four-lane, divided, controlled-access interstates traverse this section. Interstate 25 runs north and south between Sheridan and Cheyenne, and Interstate 90 runs east and west between Sheridan and Rapid City, South Dakota. (A portion of Interstate 25 remains uncompleted between Casper and Buffalo.) The area is served, in addition to Interstates 25 and 90, by a system of federal and state highways, and county, private, Bureau of Land Management, and Forest Service roads.

Figure R2-41, a traffic flow chart derived from Wyoming State Highway Department information, illustrates the volume of traffic over major roads in this eight-county region in 1975.

State Highways 59 and 387 are inadequate to handle present traffic flows. Highway 59 is the major state highway in Campbell and Converse counties, running from Douglas through Reno Junction (near the new community of Wright on State Highway 387) to Gillette and north to Broadus, Montana. Portions are narrow, winding, and rough; the highway lacks truck lanes on steep grades at present. State Highway 387 leaves U.S. Highway 87 at Midwest and goes east to Reno Junction where it meets State Highway 59. At present, this road is poor due to curves and narrowness, although portions have been improved between Midwest and the junction with State Highway 50.

Both Gillette and Campbell County have been unable to maintain local streets and roads to acceptable standards as regional energy development and the resulting rapid population growth has occurred. Of those responding to the 1977 Citizens' Policy Survey in Gillette, 88% of those residing in unincorporated portions of the county and 98% of those residing in Gillette felt that road and street maintenance needed to be improved (City of Gillette/Campbell County Department of Planning and Development). Similarly, 79% and 82%, respectively, of county and city residents felt that traffic control needed improvement.

Campbell County residents voted in favor of an optional 1% increase in the county sales tax on November 2, 1976. This increase must be renewed every 2 years.



SOURCE: WYOMING HIGHWAY DEPARTMENT, 1976

Figure R2-41

AVERAGE DAILY TRAFFIC (24 HOURS) IN 1975
EASTERN POWDER RIVER BASIN

The tax is expected to generate about $2.5 million annually, with 55% going to Gillette and 45% to Campbell County. A consultant completed a street inventory for the city during April 1977, and then during July 1977, selected priority improvements costing $3 million to be done by the city. The city will spend approximately $1.5 million, plus an additional $1.5 million of a matching funds grant from the Wyoming State Farm Loan Board, for street improvements during 1978—this amounts to about $430 per household. The county appropriated $2.2 million for county road work during fiscal year 1977-78, up 57% from the previous fiscal year.

Air Service

Seven commercial airports are within the eight northeastern counties of Wyoming. They are at Buffalo, Casper, Douglas, Gillette, Lusk, Newcastle, and Sheridan (Table R2-18).

The eight counties are served by two national carriers, Frontier and Western airlines, at Casper and/or Sheridan airports (Figure R2-42). In addition, Wyoming Airlines Ltd. provides scheduled service between Denver, Casper, and Gillette. Casper Air Service and Wyoming Central Aero-Ways provide charter service from Casper. Various energy companies and individuals operate private planes and jets out of both Casper and Gillette.

Because of the low population base in Wyoming, as well as its location outside of the national air corridors, commercial service in Wyoming is provided primarily as feeder routes to either Salt Lake City, Denver, or Minneapolis.

As growth and development increase in Wyoming, so will the use of its airways and air service. According to figures supplied by the Federal Energy Administration, the use of aviation fuel in Wyoming (a good indicator of the amount of air travel) increased approximately 30% from May 1975 to May 1976 and increased another 30% from May 1976 to May 1977 (personal communication 1977).

The Gillette-Campbell County Airport is the only airport in the Eastern Powder River Basin served by scheduled commercial service; a commuter airline provides flights to Denver. The airport is also used by several charter airlines, and corporate and private aircraft. During 1978, the Wyoming Public Service Commission will select an airline that will provide much needed intrastate scheduled air service to Gillette.

Deficiencies in the runways at Gillette currently limit the size of aircraft that may land to 12,000 pounds, which precludes service by many types of commercial aircraft. Also, the location of the airport may prevent the expansion of facilities. In summary, airport facilities need to be upgraded to meet the current demand for air service in and around the city of Gillette. The U.S. Department of Transportation granted $42,000 to the airport board to begin drafting an airport master plan. The city and county must each provide $4,200 in matching funds. Depending on the eventual findings of the study, the airport may have to be relocated. Two to 5 years will probably be required to upgrade the existing facilities, and the cost is unknown.

Bus Lines

The eight northeastern counties of Wyoming are served by two commercial bus lines: Continental Trailways and Central Wyoming Transportation Company. Continental Trailways operates north on Interstates 25 and 90 from Casper to Midwest, Buffalo, Sheridan, and Billings; north on Interstates 25 and 90 from Casper to Gillette via Buffalo; and south on Interstate 25 from Casper to Douglas and Cheyenne (personal communication, Ed Shilling 1977). Central Wyoming Transportation Company operates from Casper to Rawlins via State Highways 220 and 287.

Pipelines

Major oil and natural gas pipelines have been delineated in Figure R2-43. There are an estimated 999 miles of major pipelines presently within Campbell and Converse counties. The pipelines shown are used primarily in the transportation of petroleum products from oil and gas fields. The petroleum products shipped are crude oil, natural gas, gasoline, propane, and butane.

Electric Transmission Lines

Major electric transmission lines have been delineated in Figure R2-44. There are 370 miles of major power lines (69 kilovolt and larger) within Campbell and Converse counties.

Electrical service is furnished to the southern portion of the region by Pacific Power and Light Company. Their main source of power comes from the Dave Johnston Plant near Glenrock, which has a four-unit generating capacity of 750 megawatts. Electrical service is provided to the northern portion of the region by the Black Hills Power and Light Company and Pacific Power and Light Company; power is generated at the Wyodak Plant near Gillette.

Telephone

Converse and Campbell counties are serviced by Mountain Bell Telephone Company. The approximate number of telephones as of December 1976, was 3,412 in Converse County and 6,554 in Campbell County. In 1976, the company spent $44 million on new construction in Wyoming, and they plan to spend $50 million for growth and change in 1977 (personal communication, R.G. Peterson 1977).

TABLE R2-18

MAJOR AIR SERVICE IN EIGHT NORTHEASTERN COUNTIES OF WYOMING (1977)

County/Municipality	Principal Airport	Runway Length	Runway Lights	Service
Campbell/Gillette	Gillette Municipal	5,500 ft.*	yes	Scheduled commercial
Converse/Douglas	Converse County	5,000 ft.	yes	Charter and private only
Johnson/Buffalo	Buffalo Municipal	5,000 ft.	yes	Charter and private only
Natrona/Casper	Natrona County International	10,600 ft.	yes	Scheduled commercial**
Nibrara/Lusk	Lusk	4,790 ft.	yes	Charter and private only
Sheridan/Sheridan	Sheridan County	6,650 ft. 5,039 ft.	yes	Scheduled commercial**
Weston/Newcastle	Newcastle	4,700 ft.	yes	Charter and private only

Source: Wyoming State Department of Economic Planning and Development.

* At present, the Gillette runway has been shortened by 1,300 feet because of ground upheavals.
** Including Frontier and/or Western airlines.

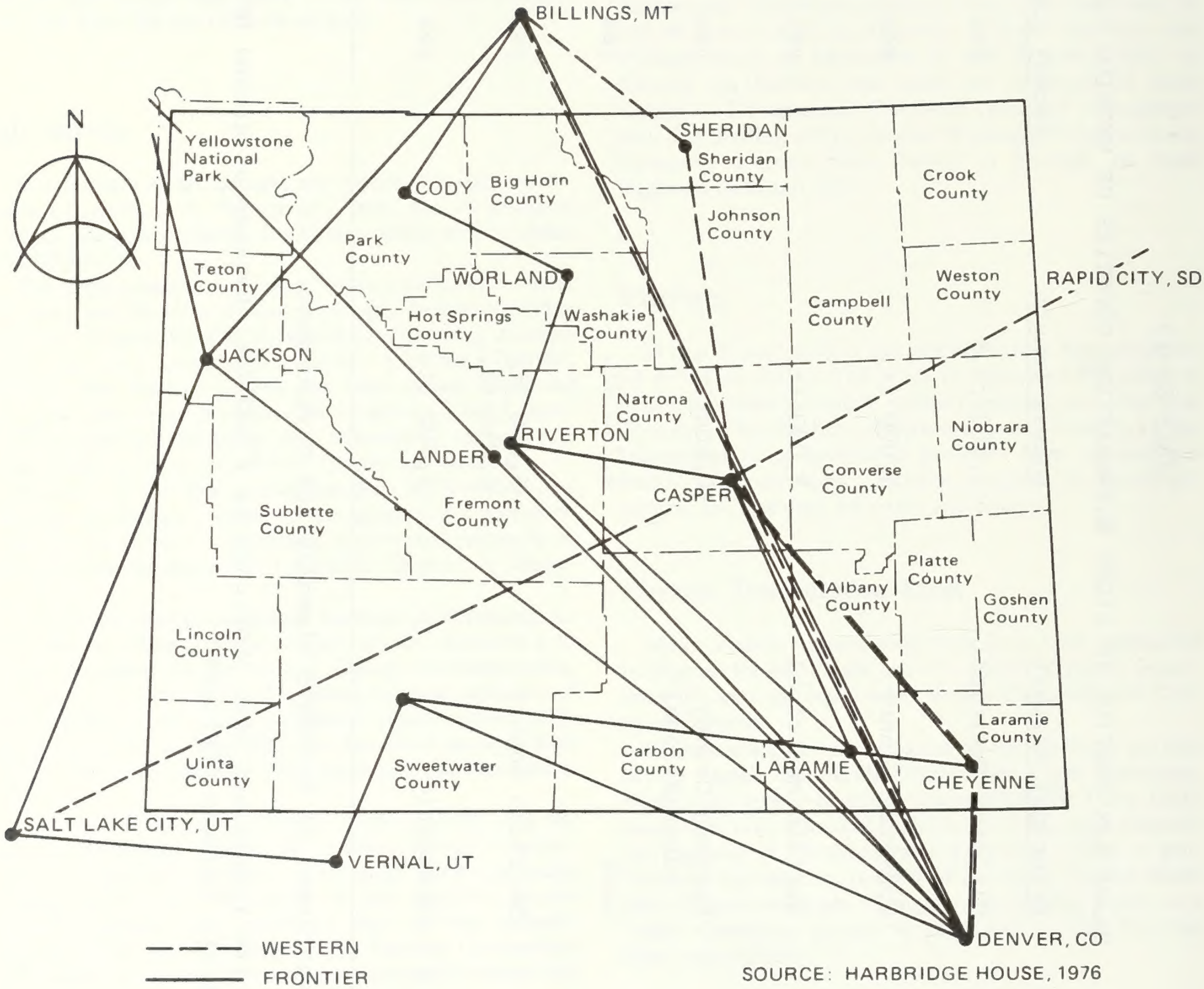


Figure R2-42
FRONTIER AND WESTERN AIRLINE ROUTES IN WYOMING

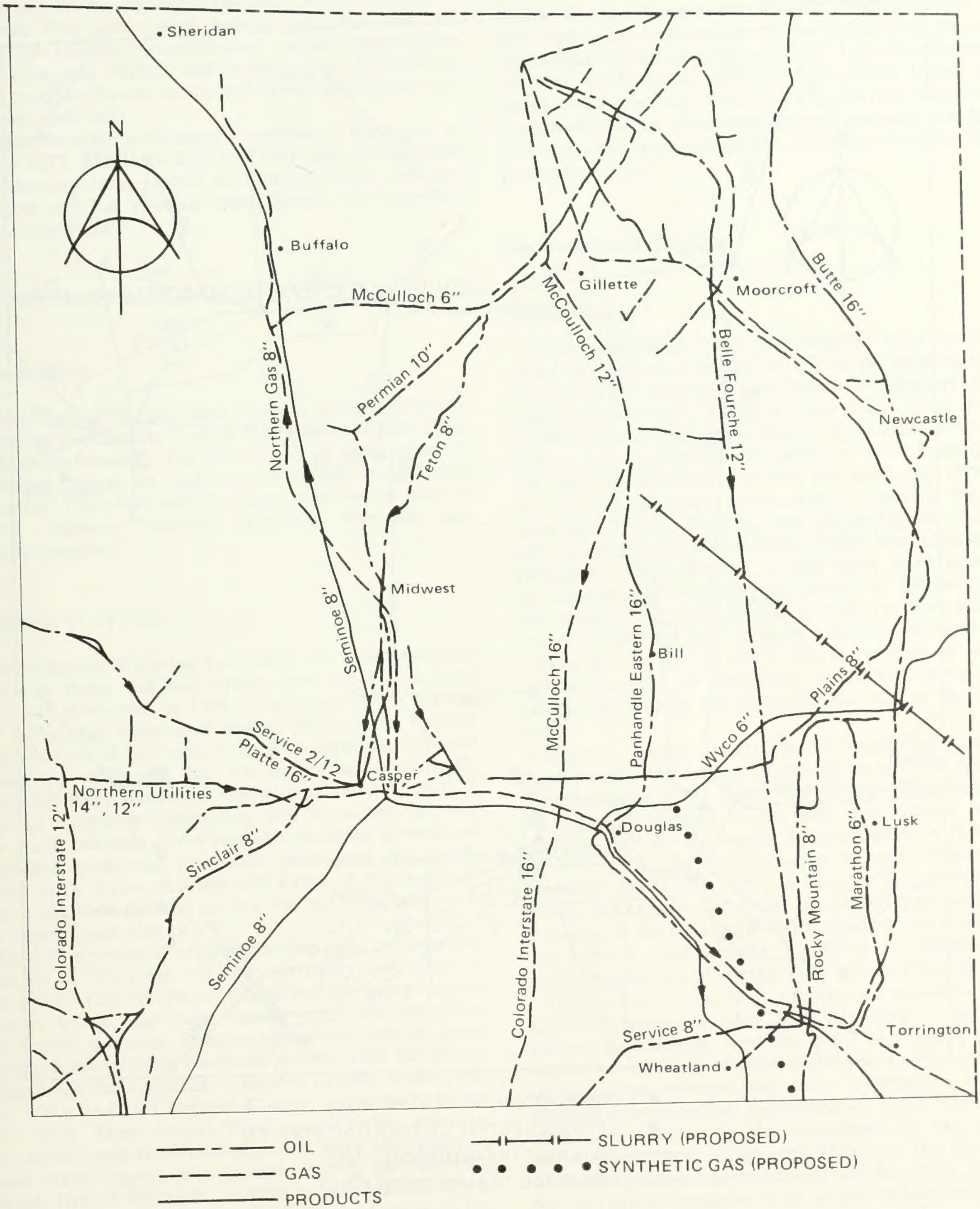


Figure R2-43
MAJOR PIPELINES IN THE EIGHT NORTHEASTERN COUNTIES OF WYOMING

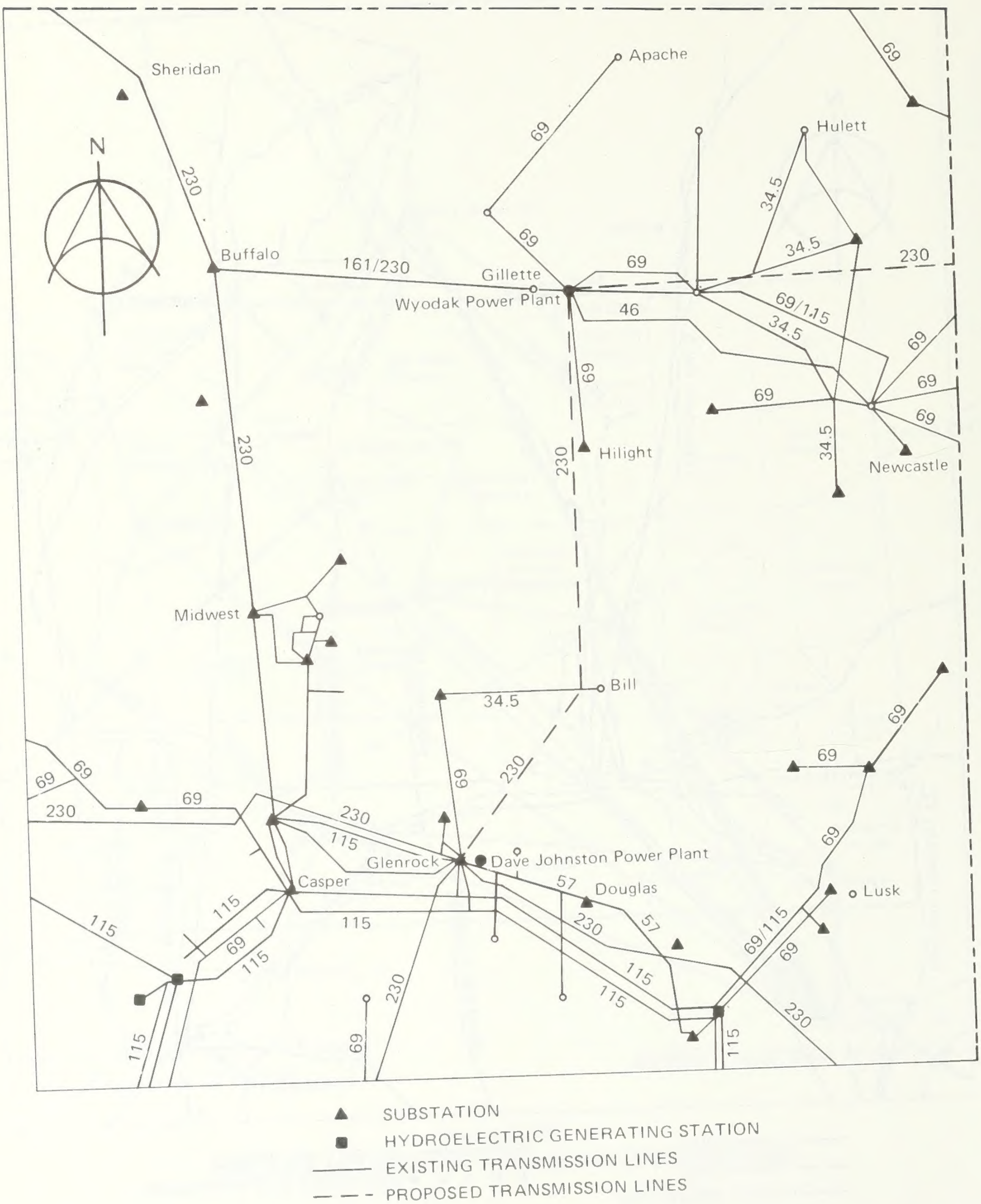


Figure R2-44
MAJOR TRANSMISSION LINES IN THE EIGHT NORTHEASTERN COUNTIES OF WYOMING

In the spring of 1976, Mountain Bell installed a new facility in Gillette, making it the most modern system in the state. This new system, besides additional lines, includes services such as solid-state memory units, automatic data and billing, call waiting, call forwarding, speed calls, conference calls, and direct dialing for collect and credit calls.

Within the eight northeastern counties of Wyoming, as of July 1977, Mountain Bell had only one underground cable running from Casper to Powder River, and one overhead toll line running from Glendo to Casper to Midwest to Buffalo.

SOCIOECONOMIC CONDITIONS

Introduction

Since many of the economic impacts of regional development in the Eastern Powder River Basin would affect neighboring counties, the description of socioeconomic conditions covers an eight-county region in northeast Wyoming: Campbell and Converse counties, as well as Crook, Johnson, Natrona, Niobrara, Sheridan, and Weston counties.

Historic Overview

Northeastern Wyoming has undergone a succession of economic boom and bust cycles since the Indian presence was eliminated in 1878. From open range grazing last century, to homestead land acquisition and farming after the turn of the century, to petroleum development during the 1950s and 60s, the region has periodically benefitted from short-term booms that did not result in regional long-term population and economic growth. The result has been a low rate of population growth and depressed economic conditions punctuated by booms which made a few rich and left wakes of social disruption. Long-term planned growth has not been a factor in the region's past history.

Overall population growth for the eight northeastern counties of Wyoming has been extremely slow since at least 1940. The exceptions to this are the energy development booms that have caused rapid but temporary population increases in some relatively limited areas. Most notable of these economic booms were the oil developments that occurred in Weston County in the 1940s and 1950s and in Campbell County, particularly in the late 1960s. These booms have caused rather dramatic population impacts in local areas but have had relatively small overall impact. For example, during the 1960-1970 period, five of the eight counties in northeastern Wyoming experienced population decreases and seven of the eight counties (with Campbell County the one exception) experienced net out-migration.

Traditionally, northeastern Wyoming has been ranching country. Many of the ranches located in this area were among the last homesteaded in the United States, and for much of the last century, ranching has been the principle way of life for the people of the area (Massey 1977). The small towns that dot the landscape were established to meet the needs of the ranchers of the vast geographic areas that surround them. Like the thousands of other small, rural, agriculture-dominated towns that characterize this area of the country, the towns of northeastern Wyoming were friendly and intimate, the pace was easy, life was predictable, and the problems were personal (ibid.).

Sociocultural Profile

Introduction

Other sections of this report describe what could be called the objective quality of life of the inhabitants of northeastern Wyoming. These objective indicators of life quality include such things as local crime rates, health statistics, educational opportunities, opportunities for recreation, and availability and quality of local housing. In this section, however, we will approach the problem from a more subjective perspective by assessing the attitudes and values, lifestyles, and psychological environment of northeastern Wyoming. While the regional developments being assessed in this study have potential implications for the objective quality of life indicators (for example, the mean income of local residents may increase, crime rates may go up as a function of rapid population growth, and so on), it also has potentially important implications for subjective values. It is these latter values that will be the focus of this part of the document.

In many impact studies, "social impact"has come to mean merely the impact of people on service agencies (Freudenburgh 1976). While this certainly is important, it has virtually nothing to do with how human beings, whether they be old-timers or newcomers to the area, are reacting to the changes being wrought. What Freudenburgh (ibid.) calls the "less tangible"considerations—things like community social integration and subjective reactions of the population to the changes that are occurring—are at least equally important in assessing the social implications of energy development projects.

Information on baseline attitudes and values in northeastern Wyoming is taken from a variety of secondary sources. Specifically, over the last 3 or 4 years, several studies have been conducted in the area that have included attitudinal surveys and other information obtained through interviews and questionnaires. Each survey contains data relevant to the description of the existing social environment of the area. However, the limitations of these available sources should also be noted. None of the surveys is areawide in its scope. Rather, each concentrates on one or more communities and/or counties. Second, none of the studies was conducted with a focus on the range of developments that are being assessed in this environmental statement. Despite these limitations, these prior studies provide data which allow the devel-

opment of a general statement of public attitudes and values in northeastern Wyoming.

In June 1977, a citizens' policy survey was conducted by the City of Gillette/Campbell County Department of Planning and Development, and their survey findings provide the most current information on local attitudes and values. Some of the results of the studies of attitudes in Buffalo and Douglas (Uhlmann et al. 1976) and Campbell County (Paanenen et al. 1976) are also used in this report.

Attitudes and Values

Although wide publicity has been given to some of the negative effects of boom towns, the one thing that stands out most clearly in all the studies is that there is great variety in the attitudes of the residents of such impacted areas, and easy generalization should be avoided.

Traditional agrarian attitudes and values common in northeastern Wyoming are being challenged by characteristics (attitudes and values) related to boom-town conditions and by the process of industrialization. The potential for conflicts between the two sets of attitudes and values is great.

Community Services. Satisfaction with selected community services and facilities in Buffalo and Douglas (1975), are shown in Table R2-19. The only major area of dissatisfaction delineated in Table R2-19 for Buffalo is its streets and roads (71% dissatisfied), and since 1975, efforts have been made to improve that problem.

In Douglas, substantial percentages of dissatisfaction are expressed in several areas: water supply (74%), mental health services (65%), and streets and roads (52%). Also, a plurality of respondents expressed dissatisfaction with city planning.

Land Use. Local government and the population of northeastern Wyoming have been historically opposed to any form of land use planning. However, there is concern about future growth of urban areas. Campbell, Converse, and Sheridan counties have prepared or are preparing needs surveys, interim concept plans, and general comprehensive plans. These actions indicate some support in the area for evaluation of land use and possible controls.

There are some indications of local attitudes toward specific land uses. For example, a major concern appears to be preservation of natural resources. In Campbell County, 44% of the respondents to an attitudes survey expressed concern about damage to the environment; while only 15% were not concerned (Blevins et al. 1974). The City of Gillette/Campbell County Citizens' Policy Survey (1977) found that 79% of the respondents agreed with the statement that zoning can protect property values and properly guide community development, if enforced. About 77% of county residents and 90% of city residents agreed with the above statement.

Government and Its Entities. The City of Gillette/Campbell County 1977 Citizens' Policy Survey indicates attitudes concerning various city and county services. Services provided in Campbell County which received the lowest ratings include county road maintenance and traffic control. The services or improvements in the city of Gillette which received the lowest ratings by its residents include water quality, street maintenance, and storm drainage. Medical services received the lowest rating of those services provided to both city and county residents with only 5.8% of the respondents indicating that they are presently adequate.

About the statement that city government is doing a good job in solving problems associated with rapid growth, 22% of the respondents said that they either agree or strongly agree and 56.7% indicated that they disagreed or strongly disagreed. A similar statement that county government is doing a good job of solving problems associated with rapid growth yielded a 27.9% rate agreement and 43.5% rate of disagreement. Public dissatisfaction with local government probably is related to the problems created by rapid population growth and boom-town conditions.

Area Development and Growth. There seems to be general ambivalence towards growth and development for the county. The majority of the people responding to the 1977 City of Gillette/Campbell County Citizens' Policy Survey felt that rapid population growth is not good for the county. But on the other hand, 75% felt that industrial development is good for the county. Apparently, population growth is perceived as a negative aspect of industrialization.

There are also indications that most residents feel growth and development is inevitable. The ambivalence arises out of a concern for the consequences of development. The residents like their towns and the friendly atmosphere, an atmosphere directed toward the old-time residents, which need not be extended to outsiders who are often viewed as fair game for exploitation. The long-time residents generally worry that growth may destroy their small-town atmosphere (Thompson et al. 1975). Residents' opinions about the possible beneficial consequences of continued development are summarized in Table R2-20. Regardless of the research site, the prevailing estimate of the general consequences of development is positive. It should be noted the questions on Table R2-20 deal only with economic, and not social, consequences of energy development.

The findings from these surveys may be summarized as follows. Those who define the projected development as *not* economically beneficial are in the minority. There is a substantial minority, somewhere between 17% and 25% of the population, who are undecided or neutral about the possible benefits of development. The largest group feels the economic consequences of development will be ultimately beneficial; however, it seems that the economic benefits defined by these people presuppose appropriate controls to ensure protection of the environment.

Paanenen and others (1976) presented tables showing the distribution of Campbell County respondents' attitudes towards strip mining, and the following discussion draws upon those percentage tables. While the Campbell County respondents generally agreed that development would bring more money, jobs, and services, they were unsure about its effects on friendship and community

TABLE R2-19

SATISFACTION WITH SELECTED COMMUNITY SERVICES AND FACILITIES, BUFFALO AND DOUGLAS, 1975

(Percent of Total)

	Buffalo				Douglas			
	Satis-fied*	Neutral	Dissatis-fied**	(N)	Satis-fied*	Neutral	Dissatis-fied**	(N)
Law Enforcement	69	10	21	(242)	89	2	9	(238)
Fire Protection	96	3	1	(224)	98	1	1	(240)
Water Supply	89	4	7	(253)	20	7	74	(257)
Sewer Service	94	2	3	(252)	60	8	32	(256)
Garbage Collection	84	7	9	(248)	66	6	28	(252)
Telephone Service	94	2	4	(245)	89	2	9	(247)
Streets, Roads	19	10	71	(254)	39	9	52	(255)
City Planning	67	14	19	(138)	36	21	43	(201)
Elem. School	88	6	7	(200)	79	7	13	(68)
High School	88	5	7	(193)	81	6	13	(67)
Day Care	87	6	7	(117)	91	8	2	(65)
Present Dwelling	87	5	8	(254)	91	5	4	(257)
Medical Services	76	5	19	(242)	70	7	23	(241)
Mental Health Services	94	3	3	(115)	20	15	65	(79)
Indoor & Outdoor Sport Facilities	68	8	25	(224)	59	21	20	(212)
Amusements	67	7	25	(224)	42	17	40	(229)

TABLE R2-19
(cont'd)
SATISFACTION WITH SELECTED COMMUNITY SERVICES AND FACILITIES, BUFFALO AND DOUGLAS, 1975
(Percent of Total)

	Buffalo				Douglas			
	Satisfied*	Neutral	Dissatisfied**	(N)	Satisfied*	Neutral	Dissatisfied**	(N)
Educational & Cultural Program	81	4	14	(202)	50	23	27	(202)
Community Recreation Program	80	5	15	(192)	63	19	17	(197)
Social Services & Welfare Program	73	10	17	(120)	63	18	18	(49)
Programs for Senior Citizens	69	10	21	(162)	94	3	3	(150)
Shopping Facilities	62	7	31	(253)	64	11	25	(252)
City Government	72	15	13	(219)	48	16	36	(237)
Organized Clubs & Activities	93	4	4	(198)	88	8	4	(229)
Mail Service	90	6	4	(252)	95	2	2	(255)
Religious Services & Churches	99	1	0	(242)	98	1	1	(233)
Household Services	73	11	17	(227)	75	4	21	(223)

Note: Figures in this table are computed from the frequency distributions calculated from the percentage tables in Uhlmann et al. 1976. "Don't Know" responses have been deleted from the percentage bases. In every case, the number of "Don't Know" responses may be computed by subtracting the (N) reported from 254.

* Including the responses, "Very Satisfied" and "Satisfied."

** Including the responses, "Dissatisfied" and "Very Dissatisfied."

TABLE R2-20

ATTITUDES ABOUT THE BENEFITS OF ENERGY DEVELOPMENT AMONG RESPONDENTS IN CAMPBELL COUNTY (1974), BUFFALO (1975), AND DOUGLAS (1975)

Item and Location	Percent of Total: Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Campbell County (N=219)					
There will be more tax money available for better schools.	17	44	18	15	6
There will be more jobs available so that young people will be able to remain here rather than having to move away.	21	58	13	8	1
We will have better community services such as improved health care.	10	33	26	25	7
Incomes for local people will improve.	10	57	15	13	5
General "Potential Development will be beneficial" composite item*	14	48	18	15	5
Buffalo (Old-timer subsample, N=160)					
Potential economic development will be beneficial	1	42	26**	29	2
Potential development will be beneficial to me personally	0	32	7**	59	1
Douglas (Old-timer subsample, N=166)					
Potential economic development will be beneficial	8	57	19**	15	1
Potential development will be beneficial to me personally	13	27	11**	34	16

Source: Paanenen et al. 1976, Uhlmann et al. 1976.

* This composite item is a summary of the above four items, weighed equally, and is intended to provide a general indicator for comparison to the responses for Buffalo and Douglas.

** "Don't Know" responses are included with "Neutral" responses. For Buffalo the proportions "Don't Know" on these items were 5% for each item; for Douglas the corresponding figures were 4% and 1%.

solidarity, being almost exactly divided (43% versus 40%) on whether it would mean a decline in these valued community characteristics. Almost half (49%) were in agreement that local autonomy would decline. As for the church, most indicated that they did not think that it would become less important.

Note that with respect to these items about potential community change, the respondents in Gillette and Campbell County were not asked if they were willing to make the trade-offs between increases in taxes, jobs, and local income and declining personal autonomy and the possibility of declining community solidarity. Instead they simply agreed, yes, tax revenues, available jobs, and local incomes would increase, possibly friendship ties would decrease, local autonomy would decrease, and no, the church would not wither away. The essential final step—were they willing to make such trade-offs—was not included in the survey, although there were some questions of this form with respect to the physical environment. So the analyst can only guess about which trade-offs would be acceptable to residents at this point.

A majority of the respondents agreed that development of strip mines would be good for Wyoming. Only slightly over a third (36%) were willing to state that the coal development was one of the best things that ever happened, but 50% agreed that in the long run they would be better off (25% were neutral about this, and only 25% disagreed), and 60% agreed that Wyoming needed the proposed mining (only 21% disagreed with the fact of Wyoming's need).

While residents agreed that coal development would be a good thing and was needed, they were not willing to sacrifice the environment to save jobs. Only one out of four respondents agreed that industry should be allowed to keep polluting if stopping operations would put people out of work, and only 23% agreed that the right to a clean environment was less important than the right to employment. The respondents recognize the need for the development, but at the same time a plurality (between 43% and 46%) would stop production rather than sacrifice the environment.

As for other perceived negative effects of development, almost half (47%) agreed that there would be some negative effects upon crops and grazing. At the same time, 50% did not feel that the strip-mining operations would use water needed elsewhere.

Finally, there was more support for a "proceed with due caution"approach than for any other item in the entire series: 77% agreed that development of the strip mines should proceed "only when we have developed adequate standards and enforcement procedures"

Variations in attitude toward development by occupation are also of some interest. Over the past decade, a large sociological literature has been developed which suggests that attitudes toward environmental preservation, conversely, toward exploitation of resources, are tied closely to one's occupation, income, and educational background. Specifically, this literature argues that the environmental movement is largely an upper middle class movement—that persons with higher educations, more prestigious occupations, and higher incomes are likely to express more favorable attitudes toward environmental preservation and more negative attitudes toward resource exploitation. However, an early study by French (1974—data actually collected in 1970) found that upper middle class persons in Johnson County, Wyoming were not disproportionately preservationist in their outlook. Further, French observed that ranchers (generally in the upper income brackets) were more favorable toward strip mining than any other occupational group. Other studies have strongly contradicted French's findings on the attitudes of ranchers. For example, the survey findings of Blevins and others (1974) and comprehensive ethnographic findings of Gold (1974) and of Freudenburgh (1976) show that persons in agriculture are more concerned about development than any other occupational group. Freudenburgh argues that the early date of the French survey may have been important in its unusual findings, as might other conditions, including the fact that the company collecting coal holdings in the Johnson County area had been promising ranchers an increased supply of irrigation water.

French's other major finding (that upper middle class persons in Johnson County were not disproportionately preservationist in their orientation) has received general support from Blevins and others (1974) in their survey of Campbell County residents. These latter researchers found that white collar persons were less willing to impose strip-mining regulations than any other occupational group included in their survey. They argue that white collar persons in the area—bankers, businessmen, etc.—may perceive themselves as having more to gain financially from mining and other related energy development in the area than any other group. This would help to account for a pro-development orientation.

Evidence accumulated by Blevins and others (1974) also suggests that residents in northeastern Wyoming (particularly in Campbell County) show somewhat less concern over development than do their neighbors in southeastern Montana. Gold (1974) has attributed this difference to what he refers to as a weaker attachment to the land and to neighbors in Wyoming, which, he feels results from larger ranch size and more frequent corporate ownership.

One aspect of community solidarity is the perception of personal influence, the notion that oneself or one's groups have an input in the decisions that are made. As shown in Table R2-21, perceptions of loss of control as development occurs are somewhat more frequent in Campbell County than in Buffalo or Douglas. The figures in the table also suggest a clear gradient in perceptions that newcomers will upset the established order, with Campbell County residents most convinced that development will mean loss of local influence, followed by Buffalo old-timers and then Douglas old-timers (49%, 39%, and 31%, respectively). In summary, there is a great deal of ambiguity or neutrality concerning this matter in Douglas, while the residents of Campbell County and Buffalo seem to have firmer opinions on the matter.

Old-timers and Newcomers. No areawide indicators of attitudes toward outside influences and people have been

TABLE R2-21

PERCEPTIONS OF LOSS OF PERSONAL INFLUENCE IN THE COMMUNITY AS A CONSEQUENCE OF ENERGY DEVELOPMENT AMONG RESPONDENTS IN CAMPBELL COUNTY (1974), BUFFALO (1975), AND DOUGLAS (1975)

	Percent of Total				
Item and Location	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Local people will lose control over important decisions that affect the community life (Campbell County, N=219)	17 49	32	13	30 38	8
Potential development will lessen my voice in the community (Buffalo, old-timer subsample only, N=160)	1 39	38	11*	50 50	0
Potential development will lessen my voice in the community (Douglas, old-timer subsample only, N=166)	1 31	30	42*	24 28	4

Source: Paanenen et al. 1976, Uhlmann et al. 1976.

* "Don't Know" responses are included in the "Neutral" category. For the Buffalo old-timers the "Don't Know" responses account for 9% of the subsample, and for the Douglas old-timers the corresponding proportion is 32%.

encountered. One study from western Wyoming provides some information which is probably relevant to eastern Wyoming, especially the boom-town areas. A survey of Rock Springs residents indicates some attitudes toward outsiders or newcomers (Old West Regional Commission 1975).

First, the results indicate virtually no nonwork contacts between long-term residents and newcomers. Second, newcomers are viewed as transients interested in "entertainment,"with a greater tendency to engage in criminal and other deviant acts. This indicates how long-term residents of a community may perceive the people moving in, and how polarization based upon misunderstandings within a community can develop. Although the criticisms are moderated by the recognition that the undesirables are a minority, outsiders are still often characterized negatively by the residents of rural communities. The people who receive such labels are usually involved in activities such as construction or new mining which competes with the current agricultural life-style. Others are labeled negatively because they have been given better jobs or opportunities than the local residents.

Summary. Conflicts in northeastern Wyoming exist between (1) traditional rural agrarian attitudes and values, and the new urban industrial attitudes and values, and (2) the individual's personal freedoms, values, and attitudes, and the needs, values, and attitudes of the mass society. Area residents generally seem to want the benefits that mining and development can bring, but they do not want the associated loss of life-style. This means that the citizenry must, and generally does, recognize that local problems must be dealt with through planning and public participation.

Life-Styles

Cultural Diversity. In the past, all northeastern Wyoming communities have shared a rural agrarian way of life. Cultural diversity is currently being created in eastern Wyoming by mineral development, industrialization, and a growing tourism industry. This diversity is particularly evident in the boom-town atmosphere of Gillette. Boom towns, such as Gillette, tend to be characterized by few friendships, religious ties, or social bonds between newcomers and long-time residents. In addition to these problems, newcomers are more likely to be dissatisfied with local services and facilities than are established residents.

Old-timers and Newcomers. Northeastern Wyoming, and especially Campbell and Converse county residents, can be separated into two basic residency groups: the old-timers that have resided in the county for more than 5 years, and the newcomers who have not. The old-timers also tend to be rural and agrarian. The newcomers tend to be less rural in terms of their pasts, and more urban now because they settle in the cities of Gillette, Douglas, and Casper rather than the rural county areas.

It is possible to distinguish some of the differences and similarities between the two groups by analyzing data collected by the Wyoming Human Services Project of the University of Wyoming in 1976. The study indicates that newcomers tend to be younger, better educated, more mobile, less rural, and have a lower unemployment rate than their old-timer counterparts in Gillette. Newcomers also depend more on mobile homes for their dwellings than do old-timers. The two groups have similarities in terms of their basic geographic backgrounds and in their racial and religious homogeneity. Both groups have a similar family size and male/female ratio, work about the same average hours per week, have high average incomes relative to the rest of the state or country, and depend heavily on development-related work for their income.

Information collected from respondents in Campbell County, Buffalo, and Douglas about the effects of energy development upon friendliness and community cohesion is presented in Table R2-22. Only one question in the Campbell County study (Paanenen et al. 1976) was directly relevant to the issue of community cohesion, and responses to that item suggest that people in Gillette and Campbell County are not at all sure that a continued influx of newcomers will be a good thing for community solidarity. Forty-three percent of the respondents agreed that "people will be less united and friendly because of the influx of many newcomers,"and many (16%) felt strongly that the newcomers would weaken community bonds.

The Campbell County respondents are unusual in their pessimism about the negative consequences of a continued influx of newcomers. In contrast, only 22% of the old-timers in Buffalo disagreed with the statement that "newcomers will be good for Buffalo,"and the proportion taking the negative position in Douglas was even smaller (9%).

Perhaps the most notable finding apparent in Table R2-22 is that the Wyoming communities studied differ in their estimation of the effects of newcomers on community friendliness and unity. Old-timers in Buffalo almost always agreed that newcomers were friendly and that interaction between old-timers and newcomers was positive (83% and 77%, respectively), while oldtimers in Douglas were somewhat less apt to agree that the newcomers were friendly (65%) and considerably less likely to characterize interaction with them as positive (47%). The statements of newcomers in the two communities corroborate this difference. In both towns the newcomers describe the old-timers as friendly and helpful (Buffalo, 83% and Douglas, 90%), but at the same time the Buffalo newcomers are more likely to describe their interaction with old-timers as friendly than are the Douglas newcomers (72% versus 45%).

Another finding relevant to the community cohesiveness is that old-timers are far more supportive of newcomers than the newcomers think they are. In Buffalo, for example, 61% of the old-timers said that newcomers would be good for the town, but only 21% of the newcomers said that they thought the old-timers thought the newcomers were a good thing. The disparity between old-timers' acceptance of newcomers and newcomers' perceptions of that acceptance was smaller in Douglas, but in the same direction: 51% of the Douglas old-timers said that the newcomers would be good for the town,

TABLE R2-22

ATTITUDES ABOUT THE EFFECTS OF ENERGY DEVELOPMENT UPON COMMUNITY COHESION AND FRIENDLINESS, AMONG RESPONDENTS IN CAMPBELL COUNTY (1974), BUFFALO (1975), AND DOUGLAS (1975)

	Percent of Total				
Item and Location	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Campbell County (N=219)					
People will be less united and friendly because of the influx on many newcomers	16	27	17	25	15
Buffalo (Old-timer subsample, N=160)					
Newcomers are friendly and cooperative	1	82	11*	6	1
Interaction between newcomers and old-timers is friendly	0	77	13*	9	1
Newcomers will be good for Buffalo	1	60	17*	20	2
Buffalo (Newcomer subsample, N=91)					
Old-timers are friendly and helpful	13	70	3	11	2
Interaction between newcomers and old-timers is friendly	1	71	10*	15	2
Old-timers think newcomers are good for Buffalo	0	21	23*	48	8
Douglas (Old-timers subsample, N=166)					
Newcomers are friendly and cooperative	2	63	33*	2	0
Interaction between newcomers and old-timers is friendly	1	46	43*	10	0
Newcomers will be good for Douglas	2	49	40*	8	1

TABLE R2-22
(cont'd)

ATTITUDES ABOUT THE EFFECTS OF ENERGY DEVELOPMENT UPON COMMUNITY COHESION AND FRIENDLINESS, AMONG RESPONDENTS IN CAMPBELL COUNTY (1974), BUFFALO (1975), AND DOUGLAS (1975)

	Percent of Total				
Item and Location	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Douglas (Newcomer subsample, N=85)					
Old-timers are friendly and helpful	12	78	5	4	2
Interaction between new-comers and old-timers is friendly	1	44	33*	21	1
Old-timers think newcomers are good for Douglas	0	39	31*	29	1

Source: Paanenen et al. 1976, Uhlmann et al. 1976.

* "Don't Know" responses were included in the "Neutral" category.

but only 39% of the newcomers said that they perceived the old-timers as defining their arrival as a good thing. Uhlmann and others (1976, p. 57) commented that the newcomers' expectation that they would not be welcomed seemed a consequence of the boom-town stereotype and their definition of how it would affect them as newcomers:

> The mixed perceptions indicate that newcomers enter the community with a certain amount of fear of being rejected by the long term residents. . . this feeling may be bolstered by the boomtown stereotype which depicts old time residents harboring resentment against the influx of new citizens. At least at this stage of development in Buffalo and Douglas, oldtimers' views do not conform to the stereotype...

It may be that as development proceeds in Douglas and Buffalo, the favorable attitudes toward newcomers will shift to parallel the essentially neutral situation in Campbell County and Gillette, where one-fifth of the people describe their feelings about the effects of the newcomers as "neutral,"and about 40% who do not view the newcomers in negative terms are counterbalanced by another 40% who do. But even this distribution is not essentially a negative one; three-fifths of the people are neutral or positive, three-fifths are neutral or negative. If one seeks negative attitudes which will confirm the boom-town stereotype, they can be found. But the neutral or positive attitudes which do not comfirm the stereotype will be noted, if they are sought out.

Psychological Environment

The history of rapid energy development in Wyoming, as in other areas of the United States (such as Alaska), often is a record of not only physical but also human damage and waste. In the past, frontier expansion in rural energy-rich areas without adequate planning has left not only scarred topography, but also cities with poor living environments which can cause human psychological problems.

Economic Environment

Information about the economic environment in Gillette and Campbell County is augmented in the site-specific portion of this document.

Population

Table R2-23 summarizes population trends in the eight northeastern counties of Wyoming since 1960. Although Campbell County experienced significant population growth in the 1960s due to oil and gas discoveries, population in the eight-county area as a whole remained relatively stable. It was not until the early 1970s that increased mining of coal in Campbell and Sheridan counties (as well as in nearby areas of Montana) and uranium in Converse County caused local and regional population to grow at a more rapid rate. In addition to the three counties in which the mining operations are situated, outlying areas (particularly Crook and Weston counties) have also experienced population growth since 1970 as a result of mining activities. Natrona County's population has grown at an accelerating rate, due largely to the status of Casper as the region's main trade center. After a long period of stagnation, Johnson County has experienced one of the region's most rapid growth rates since 1975. The small increase in Niobrara County's population between 1976 and 1978 reversed a long decline, although the current population is still almost 20% below Niobrara's 1960 population.

Employment

Table R2-24 shows trends in wage and salary employment by sector between 1970 and 1975. The sector designations correspond to those used in the University of Wyoming Water Resources Research Institute (WRRI) model. This system of sector classifications differs substantially from that used by the U.S. Bureau of Economic Analysis (BEA), especially in that it combines several BEA sectors (trade; services; transportation, communications, and utilities; and finance, insurance, and real estate) into a single "super-sector"(business and consumer services). As a result, the relative importance of the mining sector, particularly on the individual county level, is understated.

When the sector classifications used by the Bureau of Economic Analysis are used, the importance of mining as a source of employment becomes clearer. According to this classification system, mining emerges as the largest single employer in Campbell and Converse counties. Regardless of sector classifications, however, mining ranks second in Natrona and Weston and third in Crook County, and remains the third largest employer in the region as a whole.

The mining employment category includes only mine operating personnel. Mine construction employment is included in the construction sector along with other types of construction employment. Showing the effects of the increase in energy construction employment, employment in the regional construction sector grew from 6.8% to 9.4% of total wage and salary employment between 1970 and 1975. In Campbell County alone, construction employment grew from 10.1% to 16.1% of the total work force during this period.

The influence of increases in mining and related employment is also seen in low regional unemployment rates. In 1977, the unemployment for the eight counties as a group was 2.9%, compared with 3.6% for Wyoming and 7.0% nationwide. Individual county unemployment rates ranged from a low of 2.6% (Natrona County) to a high of 3.7% (Sheridan County).

Income

Tables R2-25 through R2-27 reflect the developments which were taking place in the eight-county region be-

TABLE R2-23
CURRENT AND HISTORICAL POPULATION

County / City	1960 Pop.	1970 Pop.	1970 % Change 1960-1970*	1973 Pop.	1973 % Change 1970-73	1975 Pop.	1975 % Change 1973-75	1976 Pop.	1976 % Change 1975-76	1978 Pop.	1978 % Change 1976-78
Campbell	5,861	12,957	(8.3)	12,283	(-1.7)	13,090	(3.2)	14,500	(10.8)	16,000	(5.0)
Gillette	3,580	7,763	(8.1)	7,801	(0.2)	8,215	(2.6)	NA	--	10,067	--
Other Areas	2,281	5,194	(8.6)	4,482	(-3.4)	4,875	(4.3)	NA	--	5,933	--
Converse	6,366	5,938	(-0.7)	6,860	(4.9)	8,048	(8.3)	9,400	(16.8)	9,593	(1.0)
Douglas	2,822	2,677	(-0.5)	3,056	(4.5)	3,839	(12.1)	NA	--	4,824	--
Glenrock	1,584	1,515	(-0.4)	1,868	(7.2)	2,071	(5.3)	NA	--	2,296	--
Other Areas	1,960	1,746	(-1.2)	1,936	(3.5)	2,138	(5.1)	NA	--	2,473	--
Crook	4,691	4,535	(-0.3)	4,617	(0.5)	4,883	(2.8)	5,100	(4.4)	5,148	(0.5)
Moorcroft	826	981	(1.7)	923	(-2.1)	1,030	(5.6)	NA	--	1,200	--
Other Areas	3,865	3,554	(-0.8)	3,694	(1.3)	3,853	(2.1)	NA	--	3,948	--
Johnson	5,475	5,587	(0.2)	5,499	(-0.8)	5,728	(2.1)	6,100	(6.5)	6,803	(5.6)
Buffalo	2,907	3,394	(1.6)	3,211	(-1.9)	3,385	(2.7)	NA	--	4,400	--
Other Areas	2,568	2,193	(-1.5)	2,288	(1.4)	2,343	(1.2)	NA	--	2,403	--
Natrona	49,623	51,264	(0.3)	52,197	(0.6)	55,087	(2.7)	57,000	(3.5)	58,000	(0.9)
Casper	41,085	41,917	(0.2)	42,973	(0.8)	45,034	(2.4)	NA	--	47,222	--
Other Areas	8,538	9,347	(0.9)	9,224	(-0.4)	10,043	(4.3)	NA	--	10,778	--
Niobrara	3,750	2,924	(-2.5)	2,886	(-0.4)	2,895	(0.2)	2,800	(-3.3)	3,020	(3.9)
Lusk	1,890	1,495	(-2.4)	1,586	(2.0)	1,628	(1.3)	NA	--	2,000	--
Other Areas	1,860	1,429	(-2.6)	1,300	(-3.1)	1,267	(-1.5)	NA	--	1,020	--
Sheridan	18,989	17,852	(-0.6)	18,816	(1.8)	19,294	(1.3)	21,100	(9.4)	22,501	(3.3)
Sheridan	11,651	10,856	(-0.7)	11,088	(0.7)	11,617	(2.4)	NA	--	13,400	--
Other Areas	7,338	6,996	(-0.5)	7,728	(3.4)	7,677	(-0.5)	NA	--	9,101	--

TABLE R2-23
(cont'd)
CURRENT AND HISTORICAL POPULATION

County City	1960 Pop.	1970 Pop.	1970 % Change 1960-1970*	1973 Pop.	1973 % Change 1970-73	1975 Pop.	1975 % Change 1973-75	1976 Pop.	1976 % Change 1975-76	1978 Pop.	1978 % Change 1976-78
Weston	7,929	6,307	(-2.4)	6,179	(-0.7)	6,245	(0.5)	6,600	(5.7)	6,932	(2.5)
Newcastle	4,345	3,432	(-2.3)	3,389	(-0.4)	3,421	(0.5)	NA	--	3,455	--
Other Areas	3,584	2,875	(2.2)	2,790	(-1.0)	2,824	(0.6)	NA	--	3,477	--
Region	102,684	107,364	(0.4)	109,339	(0.6)	115,900	(3.0)	122,600	(5.8)	127,997	(2.2)
Wyoming	330,066	332,416	(0.0)	352,585	(2.0)	376,309	(3.3)	390,000	(3.6)	NA	NA

Source: U.S. Department of Commerce, Bureau of the Census, November 1970, April 1977, July 1977; University of Wyoming 1978.

* Average rate of change, compounded annually.

NA = Not Available.

TABLE R2-24

WAGE AND SALARY EMPLOYMENT BY COUNTY 1970-75
(Number of Workers is Followed in Parentheses by the Percentage of Total County Employment)

County	Agriculture 1970	Agriculture 1975	Minerals 1970	Minerals 1975	Construction 1970	Construction 1975	Manufacturing 1970	Manufacturing 1975
Campbell	157 (3.3)	188 (2.9)	1,108 (23.6)	1,402 (21.9)	473 (10.1)	1,031 (16.1)	27 (0.6)	84 (1.3)
Converse	198 (10.5)	239 (7.7)	155 (8.2)	654 (21.0)	177 (9.4)	286 (9.2)	19 (1.0)	42 (1.4)
Crook	130 (11.1)	157 (11.1)	135 (11.6)	190 (13.5)	64 (5.5)	127 (9.0)	120 (10.3)	133 (9.4)
Johnson	184 (10.7)	222 (10.6)	91 (5.3)	183 (8.8)	177 (10.3)	310 (14.8)	90 (5.2)	111 (5.3)
Natrona	230 (1.1)	276 (1.0)	3,361 (16.0)	4,635 (17.4)	1,202 (5.7)	2,161 (8.1)	1,614 (7.7)	1,908 (7.2)
Niobrara	96 (10.6)	116 (13.0)	78 (8.6)	89 (10.0)	56 (6.2)	23 (2.6)	33 (3.6)	31 (3.5)
Sheridan	298 (4.7)	358 (4.9)	244 (3.8)	199 (2.7)	516 (8.1)	700 (9.6)	366 (5.8)	318 (4.4)
Weston	78 (3.8)	93 (4.0)	439 (21.3)	484 (20.6)	26 (1.3)	63 (2.7)	102 (5.0)	250 (10.6)
Region	1,371 (3.4)	1,649 (3.3)	5,611 (14.1)	7,836 (15.6)	2,691 (6.8)	4,701 (9.4)	2,371 (6.0)	2,877 (5.7)
Wyoming	4,956 (4.0)	5,978 (3.7)	11,628 (9.3)	18,300 (11.4)	7,141 (5.7)	14,659 (9.2)	7,373 (5.9)	8,571 (5.4)

TABLE R2-24
(cont'd)

WAGE AND SALARY EMPLOYMENT BY COUNTY 1970-75
(Number of Workers is Followed in Parentheses by the Percentage of Total County Employment)

County	Business and Consumer Services		Government and Education		Military		Total Wage and Salary Employment	
	1970	1975	1970	1975	1970	1975	1970	1975
Campbell	2,157 (46.0)	2,733 (42.7)	767 (16.3)	962 (15.0)	5 (0.1)	4 (0.1)	4,694	6,404
Converse	848 (44.9)	1,332 (42.9)	488 (25.8)	553 (17.8)	3 (0.2)	2 (0.1)	1,888	3,108
Crook	351 (30.1)	416 (29.5)	367 (31.5)	388 (27.5)	0 (0.0)	0 (0.0)	1,167	1,411
Johnson	733 (42.5)	799 (38.2)	448 (26.0)	466 (22.3)	0 (0.0)	0 (0.0)	1,723	2,091
Natrona	10,816 (51.5)	13,680 (51.4)	3,781 (18.0)	3,973 (14.9)	3 (0.0)	2 (0.0)	21,007	26,635
Niobrara	442 (48.7)	425 (47.5)	203 (22.4)	210 (23.5)	0 (0.0)	0 (0.0)	908	894
Sheridan	3,185 (50.0)	3,679 (50.3)	1,750 (27.5)	2,033 (27.8)	6 (0.1)	5 (0.1)	6,365	7,292
Weston	924 (44.9)	953 (40.5)	491 (23.8)	510 (21.7)	0 (0.0)	0 (0.0)	2,060	2,353
Region	19,456 (48.9)	24,017 (47.9)	8,295 (20.8)	9,095 (18.1)	17 (0.0)	13 (0.0)	39,812	50,188
Wyoming	59,667 (47.8)	73,136 (45.7)	34,146 (27.3)	39,308 (24.6)	*	*	124,911	159,952

Source: U.S. Department of Commerce, Bureau of Economic Analysis 1977.

Note: Includes full- and part-time workers.
BEA data on which this table is based delete sector employment where necessary to preserve confidentially.
In preparing this table, estimates were made of deleted items.

* Figures included under government and education.

TABLE R2-25

TOTAL AND PER CAPITA PERSONAL INCOME, 1970-75
(1975 Dollars)

County	1970 Total	1970 Per Capita	1975 Total	1975 Per Capita	Percent Change in Per Capita Income, 1970-75
Campbell	64,901,000	4,985	80,259,000	6,347	27.3
Converse	31,881,000	5,344	45,566,000	5,695	6.6
Crook	22,693,000	4,379	21,093,000	4,339	-0.9
Johnson	30,772,000	5,482	35,196,000	6,282	14.6
Natrona	302,384,000	5,871	413,769,000	7,582	29.1
Niobrara	16,125,000	5,008	13,475,000	4,718	-5.8
Sheridan	104,830,000	5,844	123,722,000	6,204	6.2
Weston	30,515,000	4,815	36,710,000	5,875	22.0
Region	604,101,000	5,626	769,790,000	6,642	18.1
Wyoming	1,758,016,700	5,263	2,273,900,000	6,079	15.5
United States	1,127,952,000	5,534	1,257,345,000,000	5,902	6.6

Source: U.S. Department of Commerce, Bureau of Economic Analysis 1977.

Note: Data converted to 1975 dollars using Western States Consumer Price Index.

TABLE R2-26

AVERAGE WAGE AND SALARY INCOME BY SECTOR, 1970-75
(in 1975 Dollars)

Sector	Average Wage and Salary Income 1970	Average Wage and Salary Income 1975	Percent Change 1970-75
Agriculture	$ 3,889/yr.	$ 4,353/yr.	11.93
Mining	207.67/wk.	248.34/wk.	19.58
Construction	241.35/wk.	276.27/wk.	14.46
Manufacturing	171.74/wk.	210.85/wk.	22.77
Business and Consumer Services	117.05/wk.	135.08/wk.	15.40
Government/Education	8,347/yr.	9,577/yr.	14.74
Military	11,610/yr.	16,415/yr.	41.39

Source: University of Wyoming 1978.

Note: Data converted to 1975 dollars using Western States Consumer Price Index.

TABLE R2-27

EARNINGS BY SECTOR 1970-75
(Thousands of Current Dollars and as a Percent of Total Earnings)

County	Farm 1970	Farm 1975	Manufacturing 1970	Manufacturing 1975	Mining 1970	Mining 1975
Campbell	5,482 (13.9)	462 (0.6)	172 (0.4)	1,242 (1.6)	10,909 (27.6)	26,057 (34.4)
Converse	5,127 (28.7)	2,479 (6.8)	98 (0.6)	355 (1.0)	1,479 (8.3)	10,183 (27.8)
Crook	5,256 (41.5)	-64	780 (6.2)	1,223 (9.6)	865 (6.8)	2,673 (21.1)
Johnson	4,747 (30.8)	1,405 (6.3)	620 (4.0)	1,311 (5.9)	830 (5.4)	3,061 (13.8)
Natrona	2,825 (1.6)	1,458 (0.4)	17,929 (10.1)	33,231 (10.1)	32,605 (18.3)	73,215 (22.2)
Niobrara	2,933 (35.4)	-289	192 (2.3)	248 (3.5)	766 (9.2)	1,469 (20.9)
Sheridan	6,335 (13.0)	2,192 (3.1)	2,756 (5.7)	3,345 (4.7)	1,500 (3.1)	3,000 (4.3)
Weston	2,906 (17.2)	955 (3.5)	1,110 (6.6)	3,356 (12.4)	3,707 (21.9)	8,440 (31.1)
Region	35,611 (10.6)	8,598 (1.5)	23,657 (7.0)	44,311 (7.6)	52,661 (15.6)	128,098 (22.0)
Wyoming	116,984 (11.7)	58,267 (3.3)	64,956 (6.5)	114,370 (6.5)	112,955 (11.3)	303,520 (17.2)

TABLE R2-27
(cont'd)

EARNINGS BY SECTOR 1970-75
(Thousands of Current and as a Percent of Total Earnings)

County	Construction 1970	Construction 1975	Consumer/Business Services 1970	Consumer/Business Services 1975	Government and Education 1970	Government and Education 1975
Campbell	4,985 (12.6)	14,883 (19.6)	15,594 (39.4)	29,404 (38.8)	2,160 (5.5)	3,430 (4.5)
Converse	1,836 (10.3)	4,471 (12.2)	6,617 (37.0)	14,676 (40.0)	2,586 (14.5)	4,263 (11.6)
Crook	772 (6.1)	1,260 (9.9)	2,784 (22.0)	4,261 (33.6)	2,137 (16.9)	3,206 (25.3)
Johnson	1,897 (12.3)	4,983 (22.5)	4,662 (30.2)	7,323 (33.0)	2,573 (16.7)	3,942 (17.8)
Natrona	14,620 (8.2)	36,844 (11.2)	84,099 (47.3)	146,495 (44.4)	24,741 (13.9)	37,227 (11.3)
Niobrara	616 (7.4)	369 (5.3)	2,585 (31.2)	3,486 (49.7)	1,150 (13.9)	1,663 (23.7)
Sheridan	5,331 (10.9)	9,619 (13.7)	21,168 (43.4)	33,290 (47.2)	11,338 (23.3)	18,555 (26.3)
Weston	461 (2.7)	1,087 (4.0)	5,569 (33.0)	9,009 (33.2)	2,739 (16.2)	4,136 (15.2)
Region	30,518 (9.1)	73,516 (12.6)	143,078 (42.5)	247,944 (42.6)	49,424 (14.7)	76,422 (13.1)
Wyoming	81,458 (8.1)	226,279 (12.8)	402,647 (40.2)	699,829 (39.7)	188,283 (18.8)	309,097 (17.5)

TABLE R2-27
(cont'd)

EARNINGS BY SECTOR 1970-75
(Thousands of Current and as a Percent of Total Earnings)

	Military		Total Income	
County	1970	1975	1970	1975
Campbell	254 (0.6)	375 (0.5)	39,556	75,853
Converse	123 (0.7)	221 (0.6)	17,866	36,648
Crook	75 (0.6)	127 (1.0)	12,669	12,686
Johnson	93 (0.6)	148 (0.7)	15,422	22,173
Natrona	872 (0.5)	1,474 (0.4)	177,691	329,944
Niobrara	49 (0.6)	75 (1.1)	8,291	7,021
Sheridan	343 (0.7)	591 (0.8)	48,771	70,592
Weston	104 (0.6)	167 (0.6)	16,596	27,150
Region	1,913 (0.6)	3,178 (0.5)	336,862	582,067
Wyoming	33,499 (3.3)	53,513 (3.0)	1,000,382	1,764,875

Source: U.S. Department of Commerce, Bureau of Economic Analysis 1977.

Note: Where source contains items which have been deleted to preserve employer confidentaility, these items have been estimated.

tween 1970 and 1975. Real per capita income in the region, already higher than the national and Wyoming averages in 1970, increased at a faster rate than either the national or the statewide average (see Table R2-25). By 1975, the regional per capita income was 12.5% higher than the nationwide average, and 9% above the average for the state of Wyoming. Natrona and Campbell counties had the highest and second highest per capita incomes, respectively, in the region in 1975. Four counties (Converse, Crook, Niobrara, and Weston) had per capita incomes below the national and statewide average in 1975. Crook County's per capita income was 36% below the 1975 national average and 40% below the corresponding figure for Wyoming.

High incomes in the eight-county region are at least partly offset by the high local cost of living, which in most of the region is considerably higher than the rest of Wyoming. According to quarterly cost of living statistics published by the Wyoming Department of Administration and Fiscal Control, Gillette ranked as the third most expensive out of the 23 communities surveyed. Four others (Douglas, Casper, Sheridan, and Newcastle) ranked in the top ten. Only two communities (Buffalo and Lusk) have cost of living indices lower than Cheyenne, which serves as the benchmark of comparisons.

It should be noted that even though the region is marked by relatively high incomes, Tables R2-26 and R2-27 indicate that the local increase in income has been unevenly distributed among different segments of the population. For example, according to Table R2-26, average weekly wages in the mining and construction sectors have been considerably higher than in the manufacturing, business, and consumer services sectors. In addition, Table R2-27 shows that mining and construction between 1970 and 1975 increased their relative shares in regional earnings, from 15.6% to 22.0% and 9.1% to 12.6% respectively. Campbell County had the highest percentage of local earnings from mining in 1975 (34.4%). With the exception of agricultural sector earnings, other sectors remained relatively stable or declined somewhat in the region as a whole, with business and consumer services remaining the largest overall source of earnings between 1970 and 1975.

Local Services

The services included under this heading comprise those services which a municipality or county provides for its own residents. On the county level, these services generally include law enforcement and fire protection. For municipalities, the range of services is usually expanded to include water, sewer, and solid waste disposal in addition to police and fire protection.

Municipal Police, Fire, Water, and Sewer Services. The following discussion highlights significant trends and major problem areas in the provision of municipal services. Detailed descriptions of service levels and facilities in each community, together with any known plans for improvements or additions, are provided in Technical Reports, available in the Bureau of Land Management Casper District Office.

Based on national and Wyoming averages, the average number of policemen required to provide effective protection is approximately 2 officers per thousand population for communities under 10,000 inhabitants, and 1.7 officers per thousand population for communities over 10,000 population. In order to ensure adequate mobility, most police departments require one police cruiser for every 3 officers (Intermountain Planners, Inc. 1975). Using these guidelines, most municipalities in the eight-county region provide adequate levels of police protection, with the exceptions of Moorcroft, Buffalo, and Casper. However, it should be stressed that these ratios are planning guidelines rather than rigidly defined standards, and must be considered in the light of local conditions. For example, according to the Casper Police Chief, Casper's current complement of 1.5 officers per 1,000 population and one patrol car per 3.7 officers is adequate for the city's needs (personal communication, Robert J. Zipay, Casper Police Chief 1978). Buffalo's low police/population ratio of 1.4:1,000 also meets the town's current requirements (personal communication, John Kaffner, Buffalo Police Chief 1978). Conversely, despite nominally favorable ratios of 2.7 officers per 1,000 population and one patrol car per 3 officers, Moorcroft's Police Chief feels his department is understaffed and underequipped to satisfy the town's police protection requirements (personal communication, Robert Green, Moorcroft Police Chief 1978).

Recommended fire department strength is based on the individual town's fire flow, which in turn is derived according to a rather complicated formula based on the town's building composition and layout. However, population may be used to approximate the required fire flow if more detailed data is unavailable (Mountain West Research 1977). Based on population, Gillette, Douglas, Moorcroft, Buffalo, and Lusk all have inadequate fire department strength, which must be remedied by water system improvements and/or the acquisition of additional pumper trucks in order to bring the local fire protection up to acceptable levels. Additional problems are encountered by the Gillette and Sheridan fire departments, which report that they are frequently hindered in responding to fire alarms by heavy coal train traffic on the rail lines which bisect the towns.

Municipalities vary in the adequacy of their water supply treatment facilities. Local water requirements are assessed using an average peak demand factor of 450 gallons per capita, although actual peak demand may vary according to the town's actual mix of residential, commercial, and industrial water users (Mountain West Research 1977). Local water supplies in Glenrock, Buffalo, Lusk, and Sheridan are adequate; the remaining communities either are undertaking or plan to undertake water system improvements to meet current and future demand.

Municipal sewage treatment facilities can be evaluated by type, capacity (using an average demand factor of 168 gallons of sewage per capita daily), or Environmental Protection Agency ratings. Current sewage treatment facilities in Gillette, Glenrock, Casper, and Newcastle are adequate to meet the present demand, but facilities in the

TABLE R2-28

SCHOOL ENROLLMENT, PUPIL/TEACHER RATIO, PERCENTAGE INCREASES IN ENROLLMENT, SYSTEM FACILITY CAPACITY 1974-75 and 1977-78

County / School District	1974-75		1977-78			
	Enrollment	Pupil/ Teacher Ratio	Enrollment	Percentage Increase 1974-77	Pupil/ Teacher Ratio	Percent of School Capacity* Occupied
Campbell-Gillette						
School District #1	3,186	15.5	4,509	41.5	14.5	95.0
Converse-Douglas						
School District #1	1,193	17.3	1,859	55.8	18.1	99
Converse-Glenrock						
School District #2	703	18.8	884	25.7	18.9	78.6
Converse County Total	1,896	18.1	2,743	44.7	18.5	88.9
Crook-Sundance						
School District #1	1,233	14.4	1,332	8.0	14.9	95.0
Johnson-Buffalo						
School District #1	1,265	16.6	1,415	11.9	17.3	91.3
Natrona-Casper						
School District #1	13,256	20.8	13,783	4.0	22.1	99.9
Niobrara-Lusk						
School District #1	622	15.0	617	0.8	15.1	90.0
Sheridan-Ranchester						
School District #1	627	13.9	736	17.4	16.7	97.6
Sheridan-Sheridan						
School District #2	3,285	20.5	3,537	7.7	21.1	99.0

TABLE R2-28
(cont'd)

SCHOOL ENROLLMENT, PUPIL/TEACHER RATIO, PERCENTAGE INCREASES IN ENROLLMENT, SYSTEM FACILITY CAPACITY
1975-75 and 1977-78

County School District	1974-75 Enrollment	1974-75 Pupil/Teacher Ratio	1977-78 Enrollment	1977-78 Percentage Increase 1974-77	1977-78 Pupil/Teacher Ratio	1977-78 Percent of School Capacity* Occupied
Sheridan-Clearmont						
School District #3	130	8.4	143	10.0	9.5	84.1
Sheridan County Total	4,042	14.3	4,416	9.3	15.7	----
Weston-Newcastle						
School District #1	1,269	16.4	1,290	1.6	16.2	77.8
Weston-Upton						
School District #7	372	14.3	426	14.5	13.4	71.0
Weston County Total	1,641	15.4	1,716	4.6	14.8	74.4
Eight-County Area	27,141	16.3	30,570	12.6	16.6	----
Wyoming	86,584	18.5	93,321	7.8	18.4	----

Source: Wyoming Department of Education 1974 through 1977.

* These figures are based on estimates provided by primary contacts in the respective school districts. Excludes rural schools.

TABLE R2-29

ADMs, ASSESSED VALUATION, SCHOOL LEVIES, REVENUES, AND EXPENDITURES

1974-75 and 1976-77

County School District	1974-75 ADMs	Total Assessed Valuation	Assessed Valuation/ ADM	Total School Levy	Total Revenues	Revenues/ ADM	Total Expen-diture	Expen-diture/ ADM
Campbell								
Gillette	3,320	193,005,737	58,134	42.630	7,580,378	2,283	7,639,069	2,301
Converse								
Douglas	1,224	65,936,827	53,870	44.060	2,451,161	2,003	2,406,888	1,966
Glenrock	692	18,967,852	27,410	52.335	976,767	1,412	919,621	1,329
Crook								
Sundance	1,256	35,018,527	27,881	43.415	2,055,722	1,637	2,083,393	1,659
Johnson								
Buffalo	1,269	36,397,885	28,682	40.645	1,830,381	1,442	1,810,872	1,427
Natrona								
Casper	13,289	179,848,258	13,534	46.160	14,204,865	1,069	14,115,142	1,062
Niobrara								
Lusk	610	19,721,374	32,330	39.523	994,575	1,630	1,003,548	1,645
Sheridan								
Ranchester	637	9,166,178	14,390	49.870	917,100	1,440	940,209	1,476
Sheridan	3,274	31,878,246	9,737	47.660	3,512,319	1,073	3,744,182	1,144
Clearmont	113	4,593,783	40,653	47.140	248,799	2,202	267,668	2,369
Weston								
Newcastle	1,248	26,063,638	20,884	43.951	1,585,139	1,270	1,632,759	1,308
Upton	396	9,351,282	23,614	45.308	553,579	1,398	551,338	1,392
Regional	29,328	629,949,587	23,051		36,910,785	1,351	37,114,689	1,358
Wyoming	85,996	1,708,945,746	19,872		113,246,446	1,317	112,896,813	1,313

TABLE R2-29
(cont'd)
ADMs, ASSESSED VALUATION, SCHOOL LEVIES, REVENUES, AND EXPENDITURES
1974-75 and 1976-77

	1976-77							
County School District	ADMs	Total Assessed Valuation	Assessed Valuation/ ADM	Total School Levy	Total Revenues	Revenues/ ADM	Total Expen- diture	Expen- diture/ ADM
Campbell								
Gillette	4,091	356,605,292	87,168	45.640	12,315,969	3,011	10,526,595	2,573
Converse								
Douglas	1,648	140,509,046	85,260	50690	4,955,939	3,007	3,751,419	2,276
Glenrock	789	40,015,370	50,717	51.210	1,933,568	2,451	1,836,038	2,327
Crook								
Sundance	1,298	51,090,059	39,361	46.420	2,673,657	2,060	2,603,011	2,005
Johnson								
Buffalo	1,370	59,003,449	43,068	44.151	2,619,549	1,912	2,511,073	1,833
Natrona								
Casper	13,631	212,785,370	15,610	49.950	18,337,481	1,345	18,855,389	1,383
Niobrara								
Lusk	681	23,918,473	35,123	43.967	1,281,311	1,882	1,253,571	1,841
Sheridan								
Ranchester	674	9,459,188	14,034	44.660	1,147,362	1,702	1,157,648	1,718
Sheridan	3,409	43,855,810	12,865	49.471	4,744,756	1,392	4,631,737	1,359
Clearmont	137	4,413,575	32,216	47.243	317,172	2,315	295,009	2,153
Weston								
Newcastle	1,294	35,469,608	27,411	49.576	2,264,100	1,750	2,074,695	1,603
Upton	468	14,887,488	31,811	46.805	818,142	1,748	819,688	1,752
Regional	29,490	992,012,728	33,639		53,409,006	1,811	50,315,873	1,706
Wyoming	90,043	2,804,216,938	31,143		160,287,848	1,781	154,967,697	1,721

Source: Wyoming Department of Education 1974 through 1977.

TABLE R2-30

HOUSING SUPPLY

	1970				1977			
City	Total Units	Single Family (Percent)	Multi-Family (Percent)	Mobile Homes (Percent)	Total Units	Single Family (Percent)	Multi-Family (Percent)	Mobile Homes & Misc. (Percent)
Gillette	2,228	1,139 (51.1)	444 (19.9)	645 (28.9)	3,845	1,623 (42.2)	680 (17.7)	1,532 (40.1)
Wright	0	--	--	--	233	0 (0.0)	0 (0.0)	233 (100.0)
Douglas	1,066	795 (74.6)	197 (18.5)	74 (6.9)	1,788	1,232 (68.9)	207 (15.4)	349 (19.5)
Glenrock	514	NA	NA	NA	661	439 (66.4)	63 (9.5)	159 (24.1)
Moorcroft	NA	NA	NA	NA	297	147 (49.5)	0 (0.0)	150 (50.5)
Buffalo*	1,295	1,007 (77.8)	227 (17.5)	61 (4.7)	1,621	1,398 (86.2)	93 (5.7)	130 (8.1)
Casper	13,365	10,246 (76.7)	2,914 (21.8)	205 (1.5)	16,269	12,034 (74.0)	3,580 (22.0)	655 (4.0)
Lusk	712	NA	NA	NA	720	NA	NA	NA
Sheridan**	4,434	3,454 (77.9)	924 (20.8)	56 (1.3)	5,250	3,993 (76.1)	477 (9.1)	780 (14.8)
Newcastle	1,226	974 (79.4)	163 (13.3)	89 (7.3)	1,368	950 (69.4)	246 (18.0)	172 (12.6)

Source: U.S. Department of Commerce, Bureau of the Census 1972; City of Gillette-Campbell County Department of Planning and Development 1978; and personal communications, Al Straessle, Converse County Planning Department; Abbie Birmingham, Tri-County Planner (Crook-Niobrara-Weston Counties); Ken Gross, Town Planner, Buffalo; Lee West, Casper City Planner's Office; Joseph Hollingsworth, Sheridan County Planner 1978.

* Buffalo data as of early 1978.
** Sheridan data as of mid-1976.

NA = Not available.

TABLE R2-31

HOUSING PREFERENCES

Type of Unit	Long-time Residents	New Construction Workers	Other New Residents
		Type of Housing Preferred* (percent)	
Single Family	86.9	45.6	70.9
Multi-family	3.4	8.8	10.7
Mobile Home	8.8	38.0	17.1
Other	0.9	7.6	1.3
		Type of Housing Demanded* (percent)	
Single Family	80.7	34.3	55.1
Multi-family	5.1	10.6	17.2
Mobile Home	13.4	45.6	25.4
Other	0.9	9.8	2.3

Source: Old West Regional Commission 1975.

Note: Numbers do not add to 100 percent due to rounding.

* Housing "preference" is the response to a question "What type of housing would you like to live in?" Housing "demand" is the response to a question "What type of housing would you be willing and able to move into if it were available?"

TABLE R2-32

CITY HOUSING MARKET CHARACTERISTICS, 1978

City	Total Units	Median Cost of Single-Family Home	Median Per Month Rental Unit Cost
Gillette	3,845	$ 55,000	$ 375
Wright	328	---	---
Douglas	1,788	50,000	325
Glenrock	661	50,000	325
Moorcroft	297	42,000	250
Buffalo	1,621	55,000	250
Casper	16,269	46,000	300
Lusk	720	50,000	250
Sheridan	5,250	58,000	250
Newcastle	1,354	40,000	250

Sources: Wyoming Department of Economic Planning and Development Industrial Development Division 1977; personal communications, Ken Gross, Town Planner, Buffalo; Crystal Perry, City Clerk, Lusk; Abbie Birmingham, Tri-County Planner (Crook/Niobrara/Weston County); and Al Straessle, Converse County Planning Commission, 1978.

remaining municipalities are either operating at maximum capacity (Lusk) or are inadequate (Douglas, Moorcroft, Buffalo, and Sheridan). Due to the high cost of constructing modern sewage treatment facilities, most of these communities face difficulties in obtaining sufficient funds for the needed improvements.

County Police and Fire Services. The rural, sparsely settled nature of most county lands makes it difficult to assess the capability of county law enforcement and fire protection agencies using published standards and planning guidelines, all of which were derived with an urbanized population in mind. Based on contacts with the various county sheriffs and fire marshalls, all jurisdictions have problems extending police and fire services to residents of remote unincorporated areas; such problems are characteristic of sparsely populated states like Wyoming. This situation is especially true of the county fire departments in the eight-county region.

Education

Many of the school systems in the eight-county region have undergone significant changes as a result of the increased mining activity in the region. The three districts with the greatest enrollment increases between 1974 and 1977 are Gillette, in Campbell County, (41.5%) and the two Converse County districts, where Douglas experienced a 55.8% rise, and Glenrock, a 25.7% increase (see Table R2-28). Overall, the area percentage increase in enrollment was 12.6%, compared with the statewide increase of 7.8% for the same period. The pupil/ teacher ratio remained fairly stable over this same 3-year period, increasing by only 0.3 pupils per teacher (see Table R2-28) for the entire area in spite of the significant enrollment increases in the heavily impacted counties. This would indicate that by and large, the school districts have been able to maintain adequate standards in this area.

School building capacity is more difficult to measure. The state of Wyoming does not collect data on school building capacity. State figures measure capacity only for purposes of its School Foundation Program. The resulting figures, called classroom units (CRUs), represent a measure of financial need, weighted according to size and type of class in such a way as not to be useful within the context of the present analysis (Wyoming State Department of Education 1976).

Capacity figures presented in Table R2-28 are estimates provided through contacts with the superintendents of the respective school districts. In several cases, officials found it extremely difficult to provide accurate estimates. This should serve as a caution to the reader regarding the precision of the data. However, the capacity figures presented in Table R2-28 are useful as a general guide to adequacy of space in the various districts.

Funding the needed school improvements has not been a severe problem, and the heavily impacted mining communities have managed adequate expansion. According to Table R2-29, revenues and expenditures per average daily member (ADM) for the eight-county region are significantly higher than the statewide figures: $2,062 in revenues per ADM, compared to the statewide figure of $1,781, and $1,926 in expenditures per ADM, compared to the Wyoming figure of $1,721.

Finally, the qualitative changes experienced by the school systems demand consideration. The chief change common to all of the impacted areas is that the itinerant character of the new population has created a demand for more special education and counseling services. This need is being met with varying degrees of intensity among the districts in the eight-county region.

Housing

Table R2-30 depicts changes in the local housing stock between 1970 and 1977. The largest proportional increases in housing capacity have occurred in Gillette (72.5% between 1970 and 1975, or an average of 8.1% annually) and Douglas (73.7% or 8.2% annually) during the same period. In most other communities the total housing stock grew between 20% and 30% over the 7-year period. Exceptions include Newcastle, where the 7-year increase was limited to just 7.8%, and Lusk, where the total number of housing units remained virtually stable at 1970 levels.

Much of this overall increase in housing consisted of mobile homes, particularly in Gillette, where mobile homes grew from 32% to 40% of the total housing stock between 1970 and 1977. Mobile homes also increased significantly as a share of the total housing stock in Douglas, where they increased from 10.2% to 19.5% of the total housing inventory between 1970 and 1977, and in Sheridan, where they increased from 1.3% to 14.8% of the total stock of housing between 1970 and 1976 (the most recent year for which statistics are available). In all communities except Buffalo, single-family housing declined in relation to the total number of housing units during the period under study. The proportion of multi-family (e.g., apartment, duplex) units also declined in most communities, but especially Sheridan, where nearly 500 dwelling units in multi-family structures were taken off the market between 1970 and 1976.

These shifts are primarily a product of changing personal housing preferences among the population, as well as inflation in the cost of housing. According to Table R2-31, while more than 80% of the long-term residents of western communities experiencing rapid energy-related population growth typically prefer single-family housing, new residents (especially construction workers) express greater acceptance of multi-family and mobile housing. In part, this shift in preferences reflects the newcomers' own perception of their transient status and lack of local roots. However, for many households, economics rather than subjective preference plays the decisive role in determining their final choice of housing type. Spiraling housing costs in many northeastern Wyoming communities have placed single home ownership beyond the means of many households, particularly those whose primary breadwinners are employed outside the relatively high-paying mining and construction sectors. Table R2-32 compares the median cost of single-family

TABLE R2-33

ABILITY OF CONSUMERS TO PAY FOR NEW HOUSING

Type of Worker Type of Unit	1977 Estimated Monthly Cost*	1977 Percent of Monthly Income**
Construction Workers		
Single Family	$310-$480	23-36
Multi-Family	$250-$375	19-28
Mobile Home	$250-$285	19-22
Energy Mining Industry Workers		
Single Family	$310-$480	26-40
Multi-Family	$250-$375	21-31
Mobile Home	$250-$285	21-24
Other Workers		
Single Family	$310-$480	40-61
Multi-Family	$250-$375	32-48
Mobile Home	$250-$285	32-36

Sources: Personal communication, Tom Schaler, Wyoming Manufactured Housing Association 1977; Wyoming Department of Economic Planning and Development, Planning Division March 1977; typical local housing costs from Table R2-32, City Housing Market Characteristics.

* In larger communities close to employment opportunities (such as Sheridan or Douglas) housing costs are noticeably higher than for smaller, more distant communities (such as Newcastle or Moorcroft). The range of values shown represents the difference between the cost of typical housing in these low-cost and high-cost communities, respectively. For a low-cost community a typical three bedroom home is $40,000, a typical three-bedroom apartment is $250 per month, and a typical site in a mobile home park is $65 per month. For a high-cost community a typical three-bedroom home can cost up to $60,000, a typical three-bedroom apartment is $325 per month, and a typical site in a mobile home park is $100 per month. Monthly costs are calculated by making the following assumptions. Single-family homes are financed with 20% down, 30-year loans at 9.25% interest. Mobile homes cost $14,000 and are financed with 20% down 15-year loans at 12% interest. Property taxes are estimated assuming taxable valuation equals one-third of property's market value, and tax rate is 50 mills per dollar of assessed valuation.

** 1977 monthly income was derived from the WRRI model's estimates of 1977 average weekly earnings for production workers in the eight-county region (University of Wyoming 1978). Categories were combined using a weighted average based on the number of workers employed in each sector.

TABLE R2-34

HEALTH FACILITIES - 1977

County	1977 Population	Hospitals					Ambulances		Nursing Care Facilities			
		Number	Beds	Occupancy (%)	Population/ Bed	Bed-Days/ Population	Number	Population/ Ambulance	Number	Beds	Occupancy (%)	Population/ Bed
Campbell	16,000	1	31	51	516	0.36	2	8,000	1	120	95	133
Converse	9,593	1	32	48	300	0.58	4	2,398	1	59	92	163
Crook*	5,148	1	16	16	322	0.18	3	1,716	0	0	--	---
Johnson	6,803	1	26	57	262	0.79	5	1,361	1	40	81	170
Natrona	58,000	1	297	61	195	1.14	8	7,250	3	247	89	235
Niobrara	3,020	1	24	31	126	0.90	2	1,510	1	12	93	252
Sheridan	22,501	1	89	67	253	0.97	5	4,500	1	120	93	188
Weston	6,932	1	36	38	193	0.72	3	2,310	1	41	92	169
REGION	127,997	8	551	46	232	0.72	32	4,000	9	639	79	187
WYOMING	424,156	27**	1,649	53	257	0.85	129	3,288	27	1,823	86	233
NATION	213,819,00	7,156	1,465,828	77	146	1.92	--	---	--	---	--	---

Sources: University of Wyoming 1978; Wyoming Department of Health and Social Services 1977; personal communication. Larry Bertilson, State Health Planning Manager 1978; American Hospital Association 1976.

* Crook county has been designated a medical scarcity area by the Wyoming Department of Health and Social Services.

** Excludes the Wyoming State Hospital, two Veterans' Administration hospitals, and the Warren Air Force Base hospital. Occupancy based on 22 hospitals for which data were available.

TABLE R2-35

HEALTH CARE PERSONNEL 1977
(Ratio of Population to Health Care Specialist)

County	1978 Population	Physicians	Psychologists	Registered Nurses	Licensed Practical Nurses	Pharmacists	Dentists
Campbell	16,000	1,778	8,000	302	727	114	4,000
Converse	9,593	1,599	9,593	331	1,066	959	4,797
Crook*	5,148	2,574	--**	468	--**	2,574	5,148
Johnson	6,803	1,701	--**	227	618	972	3,402
Natrona	58,000	725	14,500	151	301	921	1,706
Niobrara	3,020	1,510	--**	252	604	3,020	3,020
Sheridan	22,501	865	7,500	146	682	865	1,406
Weston	6,932	2,311	--**	267	990	1,155	3,466
Region	127,997	977	14,222	183	452	992	2,064
Wyoming	424,156	1,082	7,069	206	582	1,181	2,232
Recommended Standards		1,000	--	285	--	--	1,600

Sources: University of Wyoming 1978; Wyoming Department of Health and Social Services, 1977; personal communication, Larry Bertilson, State Health Planning Manager 1978.

Note: Data are from August 1977. The number of physicians used for the calculations is the number of active physicians, which is lower than the actual number of licensed physicians.

* Crook County has been designated a medical scarcity area by the Wyoming Department of Health and Social Services.

** No health care specialist in this category.

TABLE R2-36

TRENDS IN TOTAL AND PER CAPITA RETAIL SALES, 1972-75
(1975 Dollars)

	1972		1975		Percent Change 1972-75	
County	Total Retail Sales	Per Capita Retail Sales	Total Retail Sales	Per Capita Retail Sales	Total Retail Sales	Per Capita Retail Sales
Campbell	$ 41,357,000	$ 3,423	$ 44,081,000	$ 3,362	6.6	-1.8
Converse	16,372,000	2,443	18,033,000	2,240	10.1	-8.3
Crook	6,612,000	1,407	6,666,000	1,365	0.8	-3.0
Johnson	15,676,000	2,903	14,673,000	2,562	-6.4	-11.7
Natrona	184,388,000	3,486	214,571,000	3,895	16.4	-11.7
Niobrara	8,901,000	3,070	8,635,000	2,983	-3.0	-2.8
Sheridan	59,961,000	3,295	59,374,000	3,077	-1.0	-6.6
Weston	14,130,000	2,316	13,696,000	2,193	-3.1	-5.3
Region	346,104,000	3,190	379,729,000	3,276	9.7	2.7
Wyoming	1,053,805,000	3,047	1,092,250,000	2,903	3.6	-4.7

Source: Sales and Marketing Management Magazine 1976.

Note: 1972 dollars converted to 1975 dollars using Western States Conversion Price Index.

TABLE R2-37

COUNTY SHARES IN TOTAL REGIONAL SALES, 1972-1975

County	1972		1975	
	Retail Sales	Percent Share in Total Regional Sales	Retail Sales	Percent Share in Total Regional Sales
Campbell	$ 31,021,000	11.6%	$ 44,081,000	11.6%
Converse	12,676,000	4.7	18,033,000	4.7
Crook	5,119,000	1.9	6,666,000	1.8
Johnson	12,137,000	4.5	14,673,000	3.9
Natrona	142,763,000	53.3	214,571,000	56.6
Niobrara	6,892,000	2.6	8,635,000	2.3
Sheridan	46,425,000	17.3	59,374,000	15.6
Weston	10,940,000	4.1	13,696,000	3.6
Region	267,973,000	100.0	379,729,000	100.0

Source: Sales and Marketing Management Magazine 1976.

TABLE R2-38

SUMMARY TABLE: FISCAL CHARACTERISTICS OF COUNTY AND MUNICIPAL GOVERNMENTS, FISCAL 1977-78

County / City	1978 Estimated Population	Property Tax Base: Assessed Value Total	Property Tax Base: Per Capita	Property Tax Base: Mill Levy	Operating Expenditures*: Total	Operating Expenditures*: Per Capita	Total Debt and Legal Debt Margin**: Total Debt	Total Debt and Legal Debt Margin**: Legal Debt Margin (if applicable)
Campbell	16,000	349,395,990	21,837	14.229	7,665,298	479	200,000	6,905,753
Gillette	10,067	15,570,717	1,547	7.50	7,348,296	730	2,811,656	1,245,657
Converse	9,593	180,524,416	18,818	8.638	4,292,352	447	1,500,000	2,110,488
Douglas	4,824	6,971,010	1,445	10.74	1,922,840	399	266,000	
Glenrock	2,296	2,334,375	1,017	9.134	916,712	399	360,000	N/A
Crook	5,148	51,090,059	9,924	16.298	1,794,123	349	0	1,021,801
Moorcroft	1,200	1,308,563	1,090	8.00	177,700	148	50,500	N/A
Johnson	6,803	59,003,449	8,673	11.988	1,371,695	202	60,000	1,180,069
Buffalo	4,400	5,391,235	1,225	16.699	961,720	219	540,000	N/A
Natrona	58,000	212,000,000	3,655	11.150	27,182,115***	469	0	4,240,000
Casper	47,222	8,550,777	1,727	8.00	7,550,805	164	2,032,000	652,406
Niobrara	3,020	23,565,944	7,803	12.312	843,649	279	590,000	0
Lusk	2,000	3,007,976	1,504	8.00	985,956	493	0	N/A
Sheridan	22,501	57,728,573	2,565	13.147	7,207,675	320	655,000	499,571
Sheridan	13,400	23,452,389	1,750	11.543	4,243,483	317	1,760,000	1,876,192
Weston	6,932	47,138,199	6,800	11.064	2,730,843	394	0	942,764
Newcastle	3,455	5,134,305	1,486	14.305	1,340,983	388	742,000	N/A

Sources: Wyoming Department of Revenue and Taxation 1977; Local budgets.

* Total outlays minus any identifiable nonrecurrent expenditures over $10,000.

** County debit is legally limited to 2% of total assessed value. Municipal debt limits apply only to Class I cities (Gillette, Douglas, Casper, Sheridan): the latters' indebtedness is limited to 4% of assessed value for general obligation bonds, plus 4% for sewer bonds (all other bonds are exempt).

*** General fund only.

and multi-family (rental) housing in different local housing markets.

Table R2-33 places housing cost data in the context of an individual household's ability to pay these costs. Based on the common banker's rule of thumb that housing costs should take up no more than one-third of a household's income, it is immediately apparent that ownership of single-family housing is beyond the financial means of most households, except those with breadwinners in the energy or construction sectors, or with multiple wage earners.

Health Services

Tables R2-34 and R2-35 display data on health care facilities and personnel in the eight-county region. Although each county in the region has a hospital to serve the needs of its residents, the overall ratio of population to hospital beds in the eight-county region is almost 60% higher than the national average. Despite the high ratio of population to hospital beds, the regional hospital utilization ratio of 0.72 bed-days per capita is substantially below the nationwide average of 1.92. This indicates, among other factors, that many residents are traveling outside the region to obtain medical care, motivated by the scarcity of physicians, and the relatively narrow range of services offered in the region's hospitals.

Campbell County is currently served by the 31-bed Campbell County Memorial Hospital, and has an extremely high population/bed ratio of 516:1, compared with the regional average of 232:1. However, utilization of Campbell County's hospital in bed-days per capita is less than half the eight-county regional average. Evidently a sizable portion of Campbell County residents travel outside the county for medical care, a pattern which is repeated in most other counties. Natrona County, with the widest range of health care capabilities in the region, functions as a regional health care center for many residents. The 61% occupancy rate of Natrona County Memorial Hospital allows considerable room for growth before additional facilities will be required. Natrona County, along with Sheridan County, is one of the only two counties in the region with an adequate supply of physicians, registered nurses, and dentists compared with recommended standards. The average availability of health care personnel in other counties is much less favorable, especially in Crook County, which has been designated a medical scarcity area by the Wyoming Department of Health and Social Services (1977).

Retail Trade

Between 1972 and 1975, total retail sales in the eight-county region increased 9.7% when measured in constant dollar terms (see Table R2-36). On a per capita basis, retail sales in the eight-county region (measured in constant dollars) increased by 2.7%. Most of this increase was concentrated in Natrona County (i.e., Casper) in its role as the region's main trade center. However, available data for 1977 indicate that Campbell County (Gillette) and Sheridan County (Sheridan) are becoming increasingly important as regional trade centers.

Natrona County's disproportionate gain is due to its increasing status as a trade center for residents of other counties, including those outside the eight-county region (e.g., Carbon County). Additional evidence to support this conclusion is found in Table R2-37. According to this table, Natrona County accounted for 56.6% of regional retail sales in 1975, compared with 35.5% of the population. The data also indicate that Natrona County attracted an increasing percentage of regional retail sales between 1972 and 1975. Campbell and Converse counties maintained their proportional share in regional retail trade, while the remaining five counties captured decreasing shares of total retail sales in the eight-county region.

Unfortunately, comparable data on retail sales for more recent years are not available. For technical reasons, 1977 retail sales estimates based on Wyoming sales tax collections are not directly comparable with earlier data. However, these 1977 estimates of retail sales can be used to form some idea of each county's relative share in current retail sales. Retail sales tax data indicate that since 1975, Campbell, Converse, Crook, Sheridan, and Weston counties have succeeded in capturing a larger percentage of regional retail sales. Natrona County, on the other hand, is attracting a smaller share of regional retail sales, due partly to the rise of secondary regional trade centers such as Gillette in Campbell County. Johnson and Niobrara counties' share in regional sales has continued to decline.

Regional trade tends to be organized around two trade centers: Casper and, to a lesser extent, Sheridan. Casper attracts buyers from as far as Carbon County, Wyoming, while Sheridan's sphere of attraction extends into southeastern Montana. On the other hand, many residents of the easternmost counties of the eight-county region, particularly Weston and Niobrara, travel occasionally to Rapid City, South Dakota to shop. Within Campbell and Converse counties, Gillette residents often travel to Sheridan to make purchases, while Gillette itself acts as a sales magnet to many residents of neighboring small counties such as Crook and Niobrara. The net result is that it is extremely difficult to ascertain the extent to which a given county is capable of meeting its residents' own retail trade needs. It is even more difficult to estimate the extent to which an increase in local personal income related to mining employment will be translated into increased local retail sales in a given county.

Local Finances

Local communities in the eight-county region vary widely in their fiscal characteristics. Table R2-38 summarizes the salient characteristics of local finances in a format which facilitates comparisons and provides general indicators of fiscal conditions in the various communities and their ability to respond to the fiscal demands of future population growth. (School district finances are discussed separately under education.)

The assessed valuation of a community measures its potential ability to raise additional funds through property taxes, either by increases in the property tax base or by raising the mill levy (property tax rate). The property tax base can increase as a result of additional industrial, commercial, or residential development; or an increase in property market values; or an increase in the assessment ratio (in Wyoming, property is generally assessed at 25% of its market value, called the assessment ratio). The extent to which municipalities can raise the property tax rate is limited by law (8 mills for purposes other than repayment of debt and interest, plus an unlimited rate for debt and interest repayment), although in practice many communities have been able to circumvent this requirement. The county limit of 12 mills applies only to tax levies for counties' own operating purposes; again, there are various legal means of circumventing this requirement.

Assessed valuation can be compared most meaningfully on a per capita basis. In general, Campbell and Converse counties have a much higher per capita valuation than municipalities. The county tax base includes all property within the county boundaries (especially mineral-producing property), while the municipal tax base includes only property within the town or city limits (mostly residential and commercial property). For example, Campbell County's per capita assessed value (including oil and gas development) is $21,837, compared with $1,547 for the city of Gillette. As a result, while municipalities are expected to bear the burden of providing most of the additional services required by future population resulting from energy development, most of the property tax benefits of this development will go to the counties where the mineral deposits are located. The municipalities will benefit only to the extent of additional assessment on worker housing and commercial development within their boundaries. In view of the legal ceiling on property tax rates, the capacity of municipalities to increase property tax revenues by raising the tax rate is quite limited.

As a result, most municipalities will in the future become increasingly dependent on nonproperty tax revenues, both from local sources (e.g., sales taxes, permits, and license fees) and from the state and federal governments. The latter includes, but is not necessarily restricted to the following types of revenues.

Federal Transfers. Federal revenue sharing is an important revenue component. In addition, communities may be eligible to obtain grants or loans to finance infrastructure construction from federal agencies such as the Economic Development Administration, the Environmental Protection Agency, and the Farmers Home Administration.

Mineral Revenues. Communities receive 7.5% of mineral leasing royalties received by the state (from federal leases), and the county receives 2.25%. Other portions of the leasing royalties are earmarked for education and roads.

Severance Taxes. State severance taxes are 8.5% of the value of gross production. These taxes accrue directly to the state and are not returned to communities. However, a portion of the severance taxes is passed to the State Farm Loan Board to run a grant and loan program for energy-impacted communities.

Per capita operating expenditures, the amount each jurisdiction spends on providing services to its residents (excluding lump-sum capital expenditures on major new facilities and equipment items, but including debt service payments), also vary widely among individual communities. Although there is a tendency for larger communities such as Gillette or Douglas to spend more per capita on services than small communities like Moorcroft, it is impossible to generalize about Eastern Powder River Basin communities. For example, Sheridan, with a 1978 population of 13,400, spent $317 per capita on operating expenditures, compared with Lusk's operating outlays of $493 per capita for a population less than one-sixth the size of Sheridan's.

Communities may finance needed capital improvements (e.g., water system improvements or new sewage treatment facilities) either out of current revenues or by going into debt. Legal restrictions limit the ability of counties and the larger municipalities (Gillette, Douglas, Casper, and Sheridan) to incur debts. Counties may not incur debts exceeding 2% of their assessed valuation. Class I cities (i.e., Gillette, Douglas, Casper, and Sheridan) may borrow up to 4% of their assessed valuation in general obligation bonds, plus another 4% to finance sewer system improvements; other types of indebtedness are exempt from restriction. In addition to their legal ability to incur debt, communities must convince potential investors of their long-term financial viability in order to sell their bonds. Subject to this constraint, however, most communities (except Niobrara County) currently have additional unused bonding capacity.

FUTURE ENVIRONMENT

The following portion of Chapter 2 briefly describes alterations which will occur in the Eastern Powder River Basin by 1990, assuming that the site-specific action (Buckskin) is not authorized. Detailed analyses of changes expected in the region can be found in Chapters 4 and 8 (No Action Alternative).

Historically, regional activity has centered around agriculture and the railroads. Since the 1950s, activity has shifted toward energy development, and it is now apparent that the region's future is tied to that development.

Between 1978 and 1990, approximately 52,000 acres will be disturbed for coal mines and processing plants, uranium mines and mills, oil and gas sites, quarries, roads and utility lines, and urban expansion. By 1990, about 19,000 of these acres will have been reclaimed, primarily to smoothly rolling grassland; of the remaining acres, about half will be characterized by open pit and spoil topography, and the other half will be occupied by mineral processing facilities, housing, or other structures. Only the acres reclaimed will be available for livestock grazing, wildlife habitat, or other land uses.

DESCRIPTION OF THE FUTURE ENVIRONMENT

From 1978 to 1990, approximately 1,800 million tons of coal will be mined in the region, and converted to electric power or synthetic natural gas, or exported and consumed elsewhere.

Regional development will gradually increase total suspended particulate (TSP) levels, particularly around and between Gillette and Reno Junction, but not beyond Wyoming air quality standards. Combustion emissions will increase near urban areas and roadways. However, only insignificant changes in visibility and ambient concentrations of TSP, nitrogen dioxide, and sulfur dioxide are expected in the remainder of the region.

Total regional water use is projected to increase 1,000 acre-feet (less than 2% of the average total annual use) every year through 1990. The quality of surface and groundwater may be reduced by sediment and/or higher concentrations of dissolved solids in the vicinity of mines and replaced spoils (see Chapter 4, Water Resources).

By 1990, the Gillette to Douglas rail line will be completed and carrying coal traffic from the basin's mines. Some highway construction and improvements are planned to accommodate increased traffic resulting from regional development. A new electric transmission line will also be constructed to serve regional coal mines.

By 1990, regional population is projected to increase 82%, from a 1978 level of 25,500 to 46,500. Most of the population growth is expected to occur in Campbell County, primarily in Gillette (Centaur 1978). There will be a corresponding increase in demand for housing and for community services, some finite and predictable (water, schools, fire protection), and others more difficult to assess (social services). It will be difficult for Gillette to accommodate such demands, since the population influx will precede the availability of increased revenue, and since some services and facilities are already inadequate. (The same problems can be expected in Douglas, or any other community which experiences rapid population growth.)

The effects of regional population growth will be felt beyond the urban areas: traffic will increase; there will be increased demand for recreation opportunities; the traditional agricultural way of life will change to reflect the attitudes of newcomers.

See Chapter 4, Socioeconomic Conditions and Recreation, for detailed analyses of the economic and social impacts of regional development.

CHAPTER 3

PLANNING AND ENVIRONMENTAL CONTROLS

INTRODUCTION

This chapter describes the planning and environmental controls which bear on coal development.

This chapter is in three parts: (1) a list of legislation and regulations which constrain federal, state, and/or local governments when they consider authorization of coal development; (2) a discussion of land use plans, controls, and constraints; and (3) a summary of federal, state, and local agency interrelationships.

LAWS, REGULATIONS, AND POLICY GUIDANCE

Coal Leasing

Two laws that provide the basic authorities for leasing federal coal are: Mineral Leasing Act of 1920 (41 Stat. 437, as amended; 30 U.S.C. 181 et seq.) and Mineral Leasing Act for Acquired Lands of 1947 (61 Stat. 913; 30 U.S.C. 351-359).

The law that provides the basis for public land and resource management is the Federal Land Policy and Management Act of 1976 (90 Stat. 2743; 43 U.S.C. 1701-1771).

These laws are implemented by the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS) under the following regulations:

Title 43 CFR Part 3041 provides procedures to ensure that adequate measures are taken during exploration or surface mining of federal coal (among other minerals) to avoid, minimize, or correct damages to the environment (land, water, and air) and to avoid, minimize, or correct hazards to public health and safety.

Title 43 CFR Part 3500 provides procedures for leasing and subsequent management of federal coal (among other minerals) deposits.

Title 43 CFR Part 2800 establishes procedures for issuing rights-of-way to private individuals and/or companies on public lands.

The Federal Coal Leasing Amendments Act of 1975, which amended the Mineral Leasing Act of 1920, requires that a lease sale cannot occur until the lands to be leased are included in a comprehensive land use plan. The act also provides for the consolidation of leases into logical mining units, and for diligent development, operation, and production of the reserves in a logical mining unit. The act also set the minimum royalty rate at 12½% except in special cases, and increased the state share of the royalty revenues from 37½% to 50%.

Coal Development (Mining)

Title 30 CFR Part 211 governs operations for discovery, testing, development, mining, and preparation of federal coal under leases, licenses, and permits pursuant to 43 CFR Part 3500. The purposes of the current regulations in Part 211 (May 1976) are to promote orderly and efficient operations and production practices without waste or avoidable loss of coal or other mineral-bearing formations; to encourage maximum recovery and use of coal resources; to promote operating practices which will avoid, minimize, or correct damage to the environment, including land, water and air, and avoid, minimize, or correct hazards to public health and safety; and to obtain a proper record of all coal produced.

Surface Mining Control and Reclamation Act of 1977 (SMCRA) (30 U.S.C. 1201) regulates the surface mining of all coal deposits and is implemented by the Office of Surface Mining under the regulations in Title 30 CFR Part 700. Many of these regulations are similar to the 43 CFR 3041 and 30 CFR 211 regulations which regulate coal development on federal lands. The new act and regulations provide for:

1. Environmental performance standards for surface coal mining and reclamation operations (30 CFR Part 715).
2. Inspection and enforcement procedures, including the assessment of civil penalties.
3. Requirements for state programs.
4. Requirements for the federal lands program.
5. Development of the initial regulatory program to be incorporated into coal mining permits issued under state law and the federal lands program.
6. Requirements and procedures for approval of state mining permits.
7. Requirements for posting, release, and forfeiture of reclamation performance bonds.

In all cases, pursuant to Section 515 of SMCRA and Title 30 CFR 715.13, coal mining operations will be required, as a minimum, to restore the lands affected to a condition capable of supporting the use which they supported prior to any mining, or higher or better uses of which there is reasonable likelihood. Mining permits will not be approved unless the applicant has demonstrated that reclamation to the proposed postmining land use can be accomplished under a mining and reclamation plan.

In summary, surface protection and reclamation of lands mined for coal production is provided by various regulations enforced by the Department of the Interior (43 CFR 3041 and 30 CFR 700), as well as regulations enforced by the State of Wyoming (Land Quality Rules and Regulations). Surface protection and reclamation provisions are further covered under a cooperative agreement between the State of Wyoming and the the Department of the Interior. The agreement provides for cooperation in review and approval of mining and reclamation plans, as well as cooperation in monitoring and enforcing reclamation standards.

Uranium

The Nuclear Regulatory Commission is responsible for issuing source material licenses (under 10 CFR 51) for the mining, processing, and use of nuclear materials such as uranium. The Wyoming Department of Environmental Quality (DEQ) also regulates uranium mining and milling activities as they relate to air, land, and water quality, and solid waste disposal.

Industrial Siting and Land Use Planning

The Wyoming Industrial Development Information and Siting Act of 1975 requires a siting permit for industrial development costing 50 million dollars or more in 1975 dollars. The act also requires a prospective industry to furnish plans for alleviating socioeconomic impacts and providing other extensive information before a state permit is granted for construction. Control does not apply to public properties except as provided by law. The first two projects to be sited under this act were the Jim Bridger Power Plant (Sweetwater County) and the Missouri Basin Power Plant near Wheatland, Wyoming. The Wyoming Industrial Siting Administration has responsibility for the issuance of siting permits.

The Wyoming Land Use Planning Act requires completion of county land use plans by 1978. These plans could conflict with or modify some energy development proposals.

Air Quality

Specific applicable legislation and regulations relating to air quality include:

1. Clean Air Act of 1970
2. National Ambient Air Quality Standards (NAAQS)
3. New Source Performance Standards
4. Wyoming Environmental Quality Act of 1973
5. Wyoming Ambient Air Quality Regulations
6. Clean Air Act amendments of 1977

The Clean Air Act of 1970 specified that each state would be responsible for ensuring the air quality within its borders and for specifying the way that quality would be achieved and maintained.

On April 30, 1971, the Environmental Protection Agency (EPA) officially announced the primary and secondary *NAAQS (Federal Register*, April 30, 1971). The primary standards were established to protect human health, whereas the secondary standards were established to protect the public welfare from any known or anticipated adverse effects. Standards were put into effect for suspended particulate matter, sulfur oxides, nitrogen oxides, photochemical oxidants, carbon monoxide, and hydrocarbons (see Table R3-1).

The Wyoming ambient air quality standards were put into effect in accordance with the Wyoming Environmental Quality Act. On January 22, 1972, the State of Wyoming adopted air quality regulations that were slightly more stringent with respect to total suspended particulates (TSP) and sulfur dioxide (SO_2) than the NAAQS regulations. Under Article 2 of the act, the Air Quality Division of DEQ is empowered to enforce these air quality standards (see Table R3-1).

The 1970 Clean Air Act also provided the authority to establish "emission standards"(new source performance standards) for new stationary sources and for existing sources in categories for which national standards of performance had been established.

The 1977 Clean Air Act Amendments contain major revisions of the 1970 act with respect to: (1) the setting of primary standard for nitrogen dioxide (NO_2); (2) the identification of regions within individual states that do or do not meet NAAQS; (3) the strengthening of enforcement mechanisms; (4) the establishment of regulations to control criteria pollutants in addition to suspended particulates, NO_2, and SO_2; and (5) the establishment of standards for stationary sources. The 1977 amendments to the Clean Air Act established "maximum allowable increases"which limit future increases of ambient concentrations of TSP and SO_2 above baseline concentrations. Ambient concentrations in calendar year 1974 are nominally the baseline concentrations. The "maximum allowable increases"(or increments) were established for three classes of areas as a function of the desired rise in ambient TSP and SO_2 concentrations. The air quality impacts of the emissions from all "major"stationary sources use up the prevention of significant air quality deterioration (PSD) increments shown in Table R3-2. The baseline concentrations plus the increments cannot exceed the national ambient air quality standards.

The maximum allowable increases (or increments) limit the amount of air pollutant-emitting development. Class I area increments allow very little increase in ambient TSP and SO_2 levels. Very little energy-related development is possible in Class I areas. Class II area increments were designed to allow a moderate increase in ambient TSP and SO_2 levels. Class III area increments were designed to allow the maximum increases in ambient TSP and SO_2 concentrations. The highest level of energy-related development is possible in Class III areas. Regulatory measures to prevent significant air quality deterioration for the other criteria pollutants are to be promulgated by EPA in 1979.

Under the 1977 amendments, all areas of the United States were designated Class II, except for "mandatory"-

TABLE R3-1

FEDERAL AND WYOMING AIR QUALITY STANDARDS

Pollutant	Averaging Time	Federal Primary Standards*		Federal Secondary Standards*		Wyoming State Standards**	
		$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm
Sulfur Dioxide (SO_2)	Annual (Arithmetic)	80	.03			60	.02
	24-hour	365	.14			260	.10
	3-hour			1,300	.5	1,300	.5
Total Suspended Particulates (TSP)	Annual (Geometric)	75		60		60	
	24-hour	260		150		150	
Carbon Monoxide (CO)	8-hour	10,000	9	10,000	9	10,000	9
	1-hour	40,000	35	40,000	35	40,000	35
Photochemical Oxidant	1-hour	160	.08	160	.08	160	.08
Nonmethane Hydrocarbons***	3-hour (6-9 a.m.)	160	.24	160	.24	160	.24
Nitrogen Dioxide (NO_2)	Annual	100	.05	100	.05	100	.05

* Title 40 CFR Part 50, National Ambient Air Quality Standards. (Standards for averaging times of less than one year are not to be exceeded more than once a year.)

** Wyoming Ambient Air Quality Regulations, as amended in 1975. (Standards for averaging times of less than one year are not to be exceeded more than once a year.)

*** Standards set as a guide to achieve to photochemical oxidant standards.

TABLE R3-2

MAXIMUM ALLOWABLE INCREASES FOR SO_2 AND TSP FOR PREVENTION OF SIGNIFICANT AIR QUALITY DETERIORATION

Pollutant	Averaging Time	Maximum Allowable Increases ($\mu g/m^3$)		
		Class I	Class II	Class III
Sulfur Dioxide (SO_2)	Annual Mean	2	20	40
	24-hour*	8	91	182
	3-hour*	25	512	700
Total Suspended Particulates (TSP)	Annual Mean	5	19	37
	24-hour*	10	37	75

Source: 1977 Clean Air Act Amendments

Note: Under the 1977 Amendments to the Clean Air Act all areas are designated Class II except Mandatory Class I areas.

* The 3-hour and 24-hour SO_2 and 24-hour TSP concentrations can be exceeded not more than once per year.

Class I areas. At present, there are no Class III designated areas. In mandatory Class I areas, visibility cannot be impaired nor can the increments be exceeded. No mandatory Class I areas are within the Eastern Powder River Basin. The nearest mandatory Class I areas are Grand Teton and Yellowstone national parks in the northwest corner of Wyoming about 200 miles west of the Eastern Powder River Basin. Class II areas can be reclassified by the state; however, mandatory Class I areas cannot be reclassified.

Under the new PSD review procedure promulgated by the EPA on June 19, 1978, the impact of fugitive dust emissions from surface coal mines are not to be included in the air quality analyses for the PSD increments, nor for national ambient air quality standards. Fugitive dust has been defined by the EPA to be particles of native soil which are uncontaminated by pollutants resulting from industrial activity. Fugitive dust accounts for about 98% to 99% of all particulate emissions from strip mines. Particulate emissions from stationary sources (e.g., crusher) units of surface mines are typically less than 1% to 2% of the total emissions. Because the new PSD procedures were not implemented by EPA prior to the modeling effort, the regional air quality analyses has been prepared using the previous PSD regulations. The previous regulations require the air quality impact of all particulate emissions from a surface mine be analyzed for PSD review.

The EPA has indicated that each mine operator will have to employ the best management practice for fugitive dust control regardless of the predicted concentrations during operations. (EPA interprets best management practice as those procedures or techniques that can be reasonably used to control fugitive dust.) Thus, each mining plan and the Department of the Interior's approval thereof will stipulate an appropriate combination of the following fugitive dust controls.

1. Pavement or equivalent stabilization of all haul roads used or in place for more than 1 year.

2. Treatment with semipermanent dust supressants of all haul roads used or in place for less than 1 year and for more than 2 months.

3. Watering of all other roads in advance of and during use whenever sufficient unstabilized material is present to cause excessive fugitive dust.

4. Reduction of fugitive dust at all coal dump (truck to crusher) locations through use of negative pressure bag house or equivalent methods. Inclusion of conveyor and transfer point covering, and spraying, and the use of coal load-out silos.

All mining operations which have the potential to emit more than 250 tons per year of uncontrolled particulates will be required to apply for PSD permits.

Note that the Wyoming DEQ will determine on an individual mine basis the pollutant emission controls that will be required as part of their permitting process.

The 1977 amendments have been passed by the U.S. Congress and are, therefore, law. Specific regulations needed to fulfill the requirements of these amendments are being drafted by the responsible agencies. However, neither the federal agencies nor the states are relieved of the responsibility for meeting the requirements of the Clean Air Act Amendments of 1977.

Water Quality

Specific applicable legislation and regulations include:

1. Federal Water Pollution Control Act (FWPCA), as amended in 1972

2. Wyoming Environmental Quality Act of 1973

3. Water Quality Standards for Wyoming, Wyoming Department of Health and Social Services, June 28, 1973

National standards to restore and maintain the chemical, physical, and biological integrity of the nation's waters were promulgated by the FWPCA.

Wyoming water quality standards were issued in accordance with the Wyoming Environmental Quality Act of 1973. Under Article 3 of the act, DEQ's Water Quality Division is empowered to enforce these water quality standards. Important prescribed standards include those which specify maximum short-term and long-term concentrations of pollution, minimum permissible concentrations of dissolved oxygen and other matter, and the permissible temperatures of the waters of the state. Effluent standards and limitations specifying the maximum amounts of pollution and waste which may be discharged into state waters are described. Other health and water quality standards pursuant to Section 402(b) of the FWPCA are also described. Water quality standards are generally established on the basis of ultimate water use. Thus, standards for municipal water will vary from those for agricultural water use.

Water quality planning required by Section 208 of the FWPCA is in progress in the region. Wyoming has identified Campbell County as falling within a "designated area"having priority planning needs for identification of management practices necessary to maintain or improve water quality. A major emphasis is nonpoint source pollution resulting from surface disturbance such as mining. As a "designated area,"Campbell County is included in a recently completed draft water quality plan prepared by a special planning agency, Powder River Area Planning Organization, with consultation with EPA.

Converse County falls into the category of an "undesignated area"(one of twelve such counties in Wyoming). DEQ has contracted the preparation of a water quality plan for Converse County with the Wyoming Conservation Commission. A draft plan will be reviewed after April 15, 1978.

The State of Wyoming is responsible for setting water quality standards and developing all "208 plans"; however, EPA plays a monitoring and arbitration role in the process.

Solid Waste Disposal

Applicable regulations include the Wyoming Solid Waste Management Rules and Regulations 1975, these provide for submission of solid waste disposal plans to

the state by every person or municipality proposing such disposal.

Cultural Resources

Applicable authorities include:
1. Antiquities Act of 1906 (34 Stat. 225; 16 U.S.C. 431-433)
2. Historic Site Act of 1935 (49 Stat. 666)
3. Historic Preservation Act of 1966 (80 Stat. 915; 16 U.S.C. 470)
4. National Environmental Policy Act of 1969 (33 Stat. 852; 42 U.S.C. 4321, et seq.)
5. Reservoir Salvage Act of 1960 (74 Stat. 220)
6. Executive Order 11593
7. Federal Land Policy and Management Act of 1976 (96 Stat. 2743)
8. State laws as appropriate

Both federal and state antiquities acts regulate antiquities excavation and collections, and both protect historical values on public lands. They provide for fines and/or imprisonment for violators of their provisions. The Historic Preservation Act requires that certain federal undertakings be submitted for review to the National Advisory Council on Historic Preservation. Executive Order 11593 requires all federal agencies to cooperate with nonfederal agencies, groups, and individuals to insure that federal plans and programs contribute to the preservation and enhancement of nonfederally-owned historic and cultural values.

In Wyoming, no mining on, or rights-of-way across, public lands will be approved until BLM or the U.S. Forest Service (USFS), after consultation with USGS, has coordinated professional cultural resource surveys with the Wyoming State Historic Preservation Officer and has received his written comments and review. Additional surveys and mitigation may be necessary if surface evidence indicates further evaluation is necessary.

BLM and USGS have developed procedures titled "Cooperative Procedures Between the U.S. Geological Survey and the Bureau of Land Management for Protection of Cultural Resources Related to Onshore Mineral Lease Operations Exclusive of Oil, Gas, Geothermal, and Oil Shale,"dated July 28, 1977. These procedures have been implemented for coal development within the region.

Water impoundments which would inundate important cultural values can be considered, pending decisions by the State Engineer. If a planned reservoir covers public land surface or mineral estate and its water is designated for another federally approved project, it will first be assessed under the requirements of the National Environmental Policy Act and the Reservoir Salvage Act. If cultural values are located, the "criteria for effect,"as explained in detail under Section 106 of the National Historic Preservation Act and Section 2(b) of Executive Order 11593 will be initiated by any federal agency joined in the project.

Paleontology

Paleontological resources are protected under authorities contained in the Federal Land Policy and Management Act of 1976.

Railroads

The Interstate Commerce Act (49 Stat. 543, 49 U.S.C. 1(18)) requires prior approval from the Interstate Commerce Commission for the extension or new construction of a line of railroad or the abandonment of operation of a line of railroad. Exempted from this authority are spur, industrial team, switching, or side tracks located wholly within one state. Commission certification is based on a balancing of the relevant economic, technical, and environmental factors.

Mineral Protection

Oil and gas leases are in effect for much of the region. Priorities for mining or drilling for oil and gas on public lands are established by the Conservation Division of USGS. Mining operations approaching wells or bore holes that may liberate oil, gas, water, or other fluid substances must be approved in accordance with 30 CFR 211.17 and 30 CFR 211.63. Impacts of mining on oil and gas areas can be mitigated largely by agreements among operators or by technical methods such as directional drilling, drainage practices, recovery of wells lost, pipeline and flow line relocation, and pillar recovery.

Vegetation and Wildlife

Applicable authorities include:
1. Endangered Species Act of 1973 (87 Stat. 844)
2. Bald Eagle Protection Act of 1969 (16 U.S.C. 668-668c)
3. Fish and Wildlife Coordination Act of 1958 (relates primarily to water projects)

The Endangered Species Act provides protection for listed species (both flora and fauna) and their critical habitat. Prior to authorization of any federal action, the Department of the Interior will require that a survey be made to determine if listed species or their habitat may be present. If it is determined that listed species or their habitat may be present and could be affected by the proposed activities, appropriate consultation with the U.S. Fish and Wildlife Service (FWS) will be carried out. No activities will be authorized until consultation is completed as per 50 CFR 402 (January 4, 1978).

The Bald Eagle Protection Act of 1969 prohibits mining operations in any area where such activities would molest or disturb bald and/or golden eagles and/or their nests. FWS enforces this law.

The Fish and Wildlife Coordination Act of 1958 provides that FWS will be consulted on matters which

could affect navigable waters and/or any fish or wildlife resource.

Floodplains Management

Executive Order 11988, May 24, 1977, directs federal agencies to take appropriate actions to avoid, to the extent possible, long- and short-term adverse impacts associated with the occupancy and modification of floodplains. The executive order further states that federal agencies will avoid direct or indirect support of floodplain development wherever there is a practicable alternative.

Protection of Wetlands

Executive Order 11990, May 24, 1977, directs federal agencies to take approprate actions to avoid, to the extent possible, long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative.

Provisions For Revenue Sharing And Taxation

The state government provides several methods of offset energy development impacts: (1) the infusion of additional revenues to local units of government, (2) the provision of information and technical assistance, and (3) the introduction of state and local influence into the siting of energy facilities. Efforts to increase local revenues have included automatic increases in the distribution of state tax receipts, legislated increases in the distribution of the sales tax, joint powers loans, coal impact tax grants, and the enactment of an optional sales tax. The state has tried to provide information and technical assistance to local governments through the Department of Economic Planning and Development and the Industrial Development Information and Siting Act.

Local Sales Tax

Cities and counties have the option to impose a 1% sales tax.

Coal Impact Tax

The state has the option to tax mining companies to furnish a source of revenue to be spent for roads, streets, highways, water, and sewer projects. Limited funds accrued from the coal impact tax may be borrowed by local governments to upgrade certain public facilities.

Mineral Leasing Royalties

The state receives 50% of the mineral royalties from any mineral leasing projects as provided by the Federal Coal Leasing Amendments Act of 1975. A 7.50% share of these funds goes to municipalities, and a 2.25% share goes to counties. Other distributions include state highway work in counties affected by resource development (2.25%), the school foundation program (37.50%), the state highway fund (26.25%), capital outlays for higher education (6.75%), public schools capital construction (4%), and other (13.5%).

Severance Taxes

The state receives from operating coal companies 8.50% of the value of gross products extracted from mines. This 8.50% is allocated for the state general fund (2%), the permanent trust fund (2.50%), the water development account (1.50%), a capital facilities and roads fund (1.5%), and the state highway fund (1%).

Ad Valorem Revenues

Property taxes of 3.25 mills are presently collected in Campbell County for the state school equalization fund. Because of its high assessed valuation per pupil, Campbell County School District No. 1 does not receive state school equalization funds. The equalization levy is determined annually by the state and can vary from 0 to 6 mills.

Joint Powers Act

This act allows cities and counties to share revenues, facilities, and services.

LAND USE PLANS, CONTROLS, AND CONSTRAINTS

Land Use Controls

Federal

In the region of analysis, a large number of separate jurisdictional entities exercise certain types of land and resource use controls. The federal sector includes the USFS (Thunder Basin National Grasslands) and BLM (public lands and subsurface estate under certain private lands).

Development, management, use, and control of use on public lands has been principally delegated to USFS and BLM. Controls are effected through issuance or nonissuance of a variety of leases, permits, licenses, etc. Each authorization to use public lands contains provisions to control that use. Controls exercised by the federal gov-

ernment for the subsurface estate are governed by the statutes authorizing the disposition and use of that estate. Foremost among these statutes is the authority for leasing coal deposits and authority to require, as a condition of such leases, an operation-management plan and a reclamation-restoration plan. Management policy has been extended in greater detail by the National Environmental Policy Act of 1969 and the Federal Land Policy and Management Act of 1976.

In certain situations, there is a joint or multiagency sharing of particular management and control and responsibilities, such as the cooperative agreement between the Department of the Interior and the State of Wyoming for administering and enforcing reclamation operations on federal coal leases in Wyoming. The subsurface estate vested in private or state ownership would normally be governed by applicable State of Wyoming statutes.

State

The Wyoming Commissioner of Public Lands is responsible for the administration, leasing, and management of lands owned by the State of Wyoming. Under State of Wyoming statutes, the state is authorized to perform and administer certain surface land use, planning, and development activities on state, county, municipal, and privately-owned properties. Legislation which has a significant effect on land use are the Wyoming Environmental Quality Act, Wyoming State Land Use Planning Act, and the Industrial Development Information and Siting Act.

The State of Wyoming retains jurisdiction over state lands. Some of these lands were conveyed to the state as part of the act admitting Wyoming to the Union. This legislation granted Sections 16 and 36 of every township to the state for educational purposes. Use and control of these lands (including mineral leasing, rights-of-way, etc.) are governed by Wyoming law.

County

Both Campbell and Converse counties have full time planning staffs, and are developing comprehensive county plans. Under Wyoming statutes, counties have authority to effect a wide variety of controls on state-owned lands in matters not specifically reserved to the state. The authority applies only to those portions of the county that are unincorporated. A county may regulate and restrict location and use of buildings and structures; and use, condition of use, or occupancy of lands for residency, recreation, agriculture, industry, commerce, public use, and other purposes. The authority does not apply to any planning or zoning controls over lands used or occupied for the extraction or production of minerals unless reasonably necessary to protect the public good of its citizens.

Less than 1% of the land in the region is actually owned by county governments. Use and control of these lands are governed by state law and county ordinances. Control over mineral uses on these lands is vested in the State of Wyoming under the Wyoming Environmental Quality Act of 1973. This act also authorizes the state to control air quality, water quality, and solid waste management.

Municipal

Three incorporated towns or cities lie within the region. These are Gillette, Douglas, and Glenrock. Municipalities have authority to effect master plans, zoning, and other regulatory controls. The Wyoming Environmental Quality Act of 1973 preempts cities' authority to regulate and control air, water, solid waste, and land quality standards except where specifically delegated to municipalities.

Where a county or city lacks a specific authority, provisions of the Wyoming Joint Powers Act are available to enable joint exercise of power, privilege, or authority. This legislation enables two or more agencies to jointly plan, create, finance, and operate (control) water, sewage, solid waste, fire protection, transportation, and public school facilities.

Land Use Plans

Bureau of Land Management Planning

The Eastern Powder River Basin Management Framework Plan (MFP) was revised in 1977. The revised MFP is designed to serve as a guide for multiple-use management and development of the surface of public lands as well as the federal mineral estate, much of which lies under privately owned surface. The MFP area was selected to correspond with the region analyzed in 1974 (FES 74-55) and in this document. Proposals for coal development and lands of possible interest to the mining industry for potential coal development were addressed in BLM's land use planning process. Environmental costs and tradeoffs are considered in the MFP. An important aspect of the process included consultation with representatives of state government and local governments of Gillette and Douglas. Comments and suggestions received at public meetings also influenced the content of the 1977 revised MFP.

Potential socioeconomic impacts which could result from coal development are a major concern in the region. Some local and state government planners and many citizens have recommended a "go slow"approach when considering possible future coal development in the region. Since other interests have recommended unlimited development, the 1977 revised MFP attempted to strike a balance between the recommendations and considered possible development in the vicinity of the new community of Wright in an effort to help reduce impacts to Gillette and Douglas.

Other recommendations and decisions of the MFP relating to coal are as follows:

1. To manage mineral resources for efficient development, giving priority consideration to energy minerals, but at the same time, providing environmental protection and consideration of socioeconomic impacts.

2. To designate areas of potential interest for coal development which are compatible for mining under the multiple-use concept of management, and which contain uncommitted and economic coal reserves that could be developed in conjunction with certain existing operations or mining plan proposals.

3. If the results of the current regional analysis are favorable, the approval of the mining and reclamation plan for the proposed Buckskin Mine would be in accordance with multiple use objectives of the MFP.

4. Future proposed actions in support of coal mining proposals (e.g., rights-of-way) would require analyses of possible impacts. If compatible with other uses of the area and accompanied by necessary environmental stipulations, such actions would serve the multiple-use objectives of the MFP.

Any future planning surrounding the possibilities of lease phasing, scheduling, or exchange (not addressed in 1977 MFP) could be accomplished only through full involvement of state and local governments' assistance and recommendations.

U.S. Forest Service Planning

A portion of Thunder Basin National Grasslands is included within the region. A multiple use plan (MUP) covering this area was updated in December 1971. It establishes overall land use objectives for the grasslands and is the basis for all actions within the grasslands. The overall objectives on the grasslands emanate from the Multiple-Use Sustained-Yield Act of 1960 and the Bankhead-Jones Farm Tenant Act of 1937.

Two types of federal surface estate are found on the grasslands: acquired lands and public domain lands. Acquired lands were obtained from private ownership, while public domain lands have always been in public ownership. Both of these surface estates are subject to the above acts. The MUP makes both types of lands available for coal leasing subject to certain constraints and direction established by USFS. The constraints and direction relate to such issues as maintaining crucial wildlife habitat, maintaining the stability of critical ecosystems, evaluating the reclamation potential of lands to be leased, and weighing of environmental costs and sensitivities.

USFS and BLM personnel met during BLM's MFP land use planning process in order to coordinate and prioritize possible future leasing areas within the grasslands.

Local Planning

In 1968, a joint Gillette/Campbell County Planning Department was formed; it currently employs three planners. The anticipated impacts of new coal mining have had priority consideration since January 1975. The Gillette/Campbell County Planning Department completed a preliminary draft planning program during June 1977. The proposed final comprehensive plan will be reviewed and voted in 1978. The plan has been controversial, because it proposes a ban on surface mining within 3 miles (peripheral area) of the city of Gillette, and because it proposes monitoring of countywide surface coal mining for conformance to the plan. If adopted by the city and county, the plan could aid local government in handling local mine-related development. In the past, the Board of County Commissioners has allowed the development of subdivisions adjacent to federal coal leases as well as uncontrolled development in the county near the city of Gillette.

The Douglas/Converse County Area Planning Office (established in December 1974, and employing two planners in Douglas) serves the municipalities of Douglas, Glenrock, and the balance of Converse County. A comprehensive plan for Douglas, which includes a 3-mile peripheral area, was adopted by the town of Douglas and Converse County in May 1976. A similar plan for Glenrock (including a 2-mile peripheral area) is presently in the draft and review stage; it will be placed before the Converse County Commissioners and the Glenrock Town Council for consideration in the near future.

Peripheral areas ("buffer zones") proposed to surround the above towns would require any commercial or industrial development (except mining) to adhere to the respective land use plans.

Comprehensive local planning will be incorporated into federal land use plans (USFS and BLM) as these plans are revised and updated.

INSTITUTIONAL RELATIONSHIPS

Federal

Office of Surface Mining (OSM)

OSM, in consultation with the surface-management agency (BLM or USFS), USGS, and the state regulatory authority, where applicable, recommends approval or denial of surface coal mining applications (including mining and reclamation plans) to the Assistant Secretary of Energy and Minerals. OSM is the federal regulatory authority responsible for reviewing coal mining permit applications; for enforcement of all environmental protection and reclamation standards included in an approved mining permit; for monitoring of both on and off-site effects of the mining operation; and for monitoring abandonment operations within the area of operation of a federal lease.

OSM is the principal contact for all coal mining activities within the area of operation. OSM will conduct as many inspections as are deemed necessary but no less than one partial inspection quarterly and at least one complete inspection every 6 months (30 CFR 721.11(c)).

OSM, after consultation with BLM or USFS, USGS, and the operator, establishes the boundaries of the permit area for the proposed mine and approves the locations of all the mine facilities located within this boundary.

Section 523 of SMCRA requires the federal program for surface coal mining regulation to adopt those state performance standards which the Secretary determines are more stringent than the federal standards. Therefore, the performance standards enforced by OSM on a federal leasehold should be at least as stringent as those required under state law or regulations.

The Department of the Interior is negotiating a cooperative agreement pursuant to Section 523(c) of SMCRA with the State of Wyoming and other states. Whenever this agreement is consummated with the state, the OSM functions and responsibilities specified in the agreement will be delegated to the state regulatory authority. Under this agreement, OSM and the state regulatory authority will jointly review and act on mining permit applications and recommend approval or disapproval to the officials authorized to take final action on the application. The Secretary is prohibited by law from delegating his authority to approve mining plans on federal lands.

Bureau of Land Management (BLM)

BLM, after consultation with OSM, USGS, the public, and the governor, may offer for competitive lease tracts of lands found potentially valuable for development of coal. This is part of the land use planning process.

BLM formulates special requirements to be included in a lease or mining permit application concerning the management and protection of all resources other than coal and the postmining land use of affected lands.

BLM, after consultation with USGS and OSM, is responsible for the authorization of various ancillary facilities such as access roads, power lines, communication lines, and railroad spurs proposed by a mining company on federal lands outside the permit area. Rights-of-way can only be granted pursuant to Title V of the Federal Land Policy and Management Act of 1976. Rights-of-way are approved subject to standard requirements for duration of the grants, right-of-way widths, fees or costs, and bonding to secure obligations imposed by the terms and condtions of the grants. The terms and conditions applicable to rights-of-way are determined by the regulations found in 43 CFR 2800, by the BLM land use plan, and by on-the-ground evaluations.

BLM is the lead agency, in coordination with USGS and OSM, for all proposed uses other than coal mining on federal lands within a leasehold.

U.S. Geological Survey (USGS)

USGS is responsible for reviewing mining plans for development, production, and coal resource recovery requirements on federal leaseholds. USGS is responsible for assuring the maximum economic recovery of the federal coal resource and that the federal government receives fair market value for the coal resource.

U.S. Forest Service

USFS manages the national forests and grasslands in accordance with the Multiple-Use Sustained-Yield Act of 1960 (74 Stat. 2.5, 16 U.S.C. 528-531). Rights-of-way on acquired lands in the national grasslands are granted under authority of the Bankhead-Jones Farm Tenant Act (50 Stat. 525; 7 U.S.C. 1010-1013) and the Federal Land Policy and Management Act of October 21, 1976.

Historically, lands managed by USFS have been subject to mineral exploration and mining. Coal leasing development is subject to applicable laws and regulations and constraints developed in multiple-use planning.

A surface mining operation must reclaim the surface sufficiently to achieve a land configuration consistent with the purpose of the Bankhead-Jones Act and the current land use plan for the affected area.

Relationship and Special Requirements of the Federal Land Policy and Management Act, Federal Coal Leasing Amendments Act, and the Surface Mining Control and Reclamation Act (SMCRA)

The Federal Land Policy and Management Act requires development of a comprehensive land use plan prior to lease issuance. The plan must consider all resources and present and future land uses before land use allocations can be determined. Land uses on adjacent lands must also be considered prior to determination of postmining land use.

The Federal Coal Leasing Amendments Act requires that a comprehensive land use plan must be completed prior to lease issuance and that the proposed lease must be compatible with the plan. This act list specific areas which must be classified as unsuitable for surface mining.

Section 523 of SMCRA requires that a federal lands program which includes the requirements of this act be promulgated and implemented no later than August 3, 1978. Until the federal lands program is implemented, the initial regulations as required in Section 502 of SMCRA and published in final form (30 CFR 715 and 716) in the *Federal Register*, December 13, 1977, will apply, as modified, to all federal coal leases. These regulations will be modified under the authority of Sections 523(c) and 702(b) of this act to meet the requirements of the Federal Coal Leasing Amendments Act of 1975 (30 U.S.C. 181 et seq.) and the Federal Lands Policy and Management Act of 1976. The basic changes in the regulations will be that: (1) postmining land use cited in the reclamation plan will be that which is part of the surface-management agency's comprehensive land use plan; (2) permanent roads, dams, power lines, etc., to be constructed on public lands will meet the design standards of the surface managing agency; and (3) resource data collected in the process of developing the land use plan or lease stipulations will be available for use in developing the reclamation plan.

The following is a discussion of the relationship among specific requirements of the three laws. The specific sections below serve as mitigatory measures.

Surface Owner Consent. Pursuant to Section 714 of SMCRA, where coal owned by the United States falls under private surface, the Secretary of the Interior shall not enter into any lease until the surface owner has given written consent to enter and commence a surface mining operation.

Alluvial Valley Floors West of the 100th Meridian, and Prime Farmland. Soils, geomorphic, biological, and land use information will be utilized to inventory lands to determine whether they should be classified as alluvial valley floors and prime farmland. A mining and reclamation plan which proposes to conduct a surface coal mining operation on or adjacent to alluvial valley floors shall include baseline data and surveys as prescribed in 30 CFR 715.17(j) to establish standards which ensure the preservation of the hydrologic function of these alluvial valley floors. Prior to approval to mine on lands classified as prime farmlands, the operator will have to provide data to demonstrate that his proposed method of reclamation will achieve, within a reasonable time, equivalent or higher levels of yield after mining as existed before mining. If approved, special soils handling and storage stipulations will be included in the mining plan.

Lands Classified as Unsuitable for Surface Coal Minint. Lands proposed for surface mining, as well as lands included in petition applications requesting the designation of coal lands as unsuitable for surface coal mining will be processed through the surface-management agency's land use planning and public involvement procedures. Petition applications should be filed with OSM. Prior to designating lands unsuitable for mining, except those specific tracts of land described in Section 522(e) of SMCRA, the surface-management agency shall prepare a statement on: (1) the potential coal resources of the area; (2) the demand for the coal resources; and (3) the impact of such a designation on the environment, the economy, and the supply of coal. The Federal Land Policy and Management Act also provides for classification of "Areas of Critical Environmental Concern"

Archeological Historical Sites and Endangered and/or Threatened Species. Inventories will be conducted on lands to be impacted by the surface-management agency, and stipulations necessary for the management and protection of these resources will be included in the mining permit.

Federal Lessee Protection. Prior to approval of a mining and reclamation plan, the surface of the public lands will be inventoried for legally installed appurtenances. Agreements with the federal lessee will be reached or bonds will be obtained to ensure that the lessee's investments are protected.

Reclaimability to Present Use. Prior to approval of a mining and reclamation plan, it must be demonstrated that the land can be reclaimed to its premining productive capability. Where the determination is made that certain lands cannot be reclaimed to the approved postmining land use, surface mining will not be permitted.

Performance Bonds. Surety bonds are required at the time of lease issuance and may be adjusted prior to approval of the reclamation plan. Minimum surety for reclamation is set by SMCRA at $10,000. In addition, a surety bond will be required to ensure payment to the government for each ton of coal mined.

Use of Explosives. The requirements of 30 CFR 748 will be included as part of any mining and reclamation plan submitted for approval.

Water Rights. The area around the proposed mining area will be inventoried for water uses and water rights. Special requirements will be included in the mining and reclamation plan to protect the water rights of others.

Revegetation. To ensure that the proposed reclamation plan is being developed to meet the objectives of the postmining land use, the composition and density of plants necessary to meet those objectives will be listed in the mining permit application. The surface-management agency will inspect leases and permit areas for compliance with terms, conditions, and stipulations relating to the management and protection of federal lands and resources and postmining land use.

Impoundments. The regulations provide standards and requirements for dams constructed of or impounding waste material. Requirements are also established in the regulations for permanent impoundments.

Public Health and Safety. The authorized representative of OSM has the authority to enter and inspect for compliance with the initial performance standards in 30 CFR 715 and 716. He has the authority to order a cessation of mining or reclamation operations if, in the course of an inspection or investigation, he finds conditions, practices, or violations of the initial performance standards which create an imminent danger to the public health and safety, or conditions or practices which can be expected to cause significant environmental harm.

The Public. Any person who is or may be adversely affected by a surface mining operation may notify the Regional Director of OSM (or his representative responsible for conducting inspections) in writing of any violation of SMCRA which he has reason to believe exists at the surface mine site.

State and County

State of Wyoming

DEQ. The Department of the Interior is negotiating a cooperative agreement with the State of Wyoming pursuant to Section 523(c) of SMCRA. Whenever this agreement is consummated with the state, the OSM functions and responsibilities specified in the agreement will be delegated to the state regulatory authority (DEQ). Under this agreement, OSM and DEQ will jointly review and act on mining permit applications and recommend approval or disapproval to the officials authorized to take final action on the plans. The Secretary is prohibited by law from delegating his authority to approve a mining plan on federal lands. Under the terms of the cooperative agreement, DEQ will serve as the authorized

representative of OSM in inspection and enforcement of the reclamation provisions of a mining permit.

DEQ has authority relating to air quality, solid wastes, water quality, mining, and mined-land reclamation. Standards for reclamation are determined by DEQ on an individual mine basis, after evaluation of the project and its location. The Land Quality Division issues permits and licenses to mine according to the approved mining and reclamation plans. The Air Quality Division issues permits to construct and operate coal mines after approval of plans for monitoring and controlling air contaminants. The Water Quality Division issues permits to construct settling ponds and waste water systems. They also issue National Pollutant Discharge Elimination System permits for discharging waste water. The Solid Waste Division issues construction fill permits and industrial waste facility permits for solid waste disposal during construction and operation of a coal mine.

Commissioner of Public Lands. Utility lines, roads, and railroad spurs crossing state land require easements from the Commissioner of Public Lands.

Wyoming Highway Department. Relocation of highways and all utility line crossings of state and federal aid highways require authorizations from the Wyoming Highway Department.

Wyoming State Engineer. Use of surface or groundwater for mining and coal processing operations requires a permit from the State Engineer. Water pipelines also require permits from the State Engineer.

Relationship With Private Interests

Interaction between private and federal property interests occurs frequently in the Powder River Basin, resulting from the historical federal practice of conveying land to private ownership with reservation to the United States of some or all minerals underlying the land. The acts of June 22, 1910 (30 U.S.C. 83-85) and July 17, 1914 (30 U.S.C. 121-124) were the earliest federal statutes calling for this reservation. The reservations required by those acts were limited to specific minerals, most commonly oil and gas or coal.

In the case of reservation of coal, the act of June 22, 1910 provides that any person having rights to prospect for or mine the coal may enter and occupy the land for that purpose. He must first pay the surface owner for damages caused by his operation or post a bond to cover those damages.

By far the most common reservation of minerals occurs with lands which passed to private ownership under the Stockraising Homestead Act of December 29, 1916 (39 Stat. 862; 43 U.S.C. 291-302). Section 9 of that act provides that all conveyances of land under its provisions shall contain a reservation to the United States of all minerals, together with the right to prospect for, mine, and remove them. In addition, the law spells out in some detail the relative rights of the surface owner and the holder of mineral rights. Again, there is provision for posting of bond by the holder of any mineral rights (lease) for the benefit of the surface owner if agreement with the surface owner cannot be reached. Liability of the holder of mineral rights is limited to damage to crops (including forage) or other tangible improvements. Damages for reduction in the value of land for grazing can be awarded pursuant to the act of June 21, 1949 (63 Stat. 215; 30 U.S.C. 54).

Bonds posted under the above acts are filed with the BLM. If amounts of the bonds are protested as inadequate by the landowner, BLM must decide the proper amount.

In recent years, BLM has further concerned itself with protecting interests of surface landowners when it proposes to issue new coal leases. Protection of facilities critical to ranching operations is of particular concern. BLM consults with the landowners when preparing stipulations for inclusion in coal leases. BLM field offices make similar contacts with landowners when reviewing lessees' proposed mining plans which are submitted to BLM by USGS for comment and recommendations. (Surface owner consent for mining is now also required by SMCRA.)

The Wyoming Environmental Quality Act also contains provisions to protect interests of a surface landowner where the surface and mineral estates are split. In such instances, a mining permit may not be issued without consent of the surface owner or the posting of a bond for the surface owner's benefit to secure payment of any damages "to the surface estate, to the crops and forage, or to the tangible improvements"of the landowner. Under both federal and state laws, if the extent of compensable damages cannot be agreed on by the parties, the landowner must sue for damages in court.

Private interests do not have any legal control over location of railroads or other public utility facilities in Wyoming; such utilities are authorized by state law to condemn lands where needed for their purposes, subject only to payment of compensation for the market value of the taking.

CHAPTER 4

ENVIRONMENTAL IMPACTS OF REGIONAL DEVELOPMENT

INTRODUCTION

This chapter discusses the impacts that would result from all expected developments in the region through 1990, including those related to coal, to other minerals, and to urban expansion. Cumulative regional development includes the proposed Buckskin Mine, which is the site-specific action under consideration in this environmental statement. For specific impacts of the Buckskin Mine, the reader is referred to the site-specific portion of this environmental statement.

The impact analysis which follows updates that in the previous Regional Environmental Statement (FES 74-55).

CLIMATE

The redistribution of soils and other materials at the mines, railroad, and transmission lines proposed for the region may cause small changes in the local climate. The modification of surface contours and albedo may cause local changes in wind speeds and directions, temperatures, and relative humidities. Any change in the number of thunderstorms caused by the lack of vegetation at the active mining areas would be localized.

AIR QUALITY

Introduction

Air quality impacts caused by coal developments and related activities in the Eastern Powder River Basin are addressed assuming a normal (or average) level of pollution control. These controls include a normal precipitation pattern over the region as well as no new coal fires. Any existing fires may contribute to ambient concentrations of total suspended particulates (TSP), but they are already included in the baseline TSP concentrations.

The impacts of all activities in the region are assessed for 1980, 1985, and 1990. The pollutant concentrations are compared to the national and Wyoming ambient air quality standards.

Emissions

Air quality modeling requires as inputs the pollutant emissions for each source modeled. Emissions were estimated for six different types of sources—surface coal mines, uranium mines and mills, coal-fired power plants, a coal gasification plant, towns, and transportation. (See Map 1, Appendix A for locations of these sources.)

Coal mines would be major contributors of particulate emissions in the region. Fugitive dust emissions would result from a number of activities within the mines, including blasting, coal and overburden loading and dumping, haul road and access road traffic, and wind erosion of exposed areas. For these operations, emission factors from the documents prepared by PEDCo Environmental, Inc. (1978a), the Wyoming Department of Environmental Quality (1976), and Cowherd et al. (1974) were used to relate the level of activity of an operation to fugitive dust emissions. Mines that are required to be reviewed by the Environmental Protection Agency for prevention of significant air quality deterioration will apply best management practices to control fugtive dust emissions. Operating information was extracted from individual mining and reclamation plans on file with the Area Mining Supervisor, U.S. Geological Survey. The annual emissions of particulates from regional coal development for 1980, 1985, and 1990 are shown in Table R4-1.

The uranium mills and mines also generate significant amounts of fugitive dust. The major sources of fugitive dust from the uranium mines include mining operations, access roads, ore crushing and screening, conveying, and handling. Emissions were estimated using emission factors similar to those for coal mining. The annual particulate emissions from the uranium mines and mills for the study years are also listed in Table R4-1.

Small amounts of hydrocarbon, carbon monoxide, and oxides of nitrogen are released from vehicles, steam generators, and other combustion sources within coal and uranium mines. Because of the small quantities emitted, the effects on surrounding air quality are expected to be insignificant (U.S. Department of the Interior 1976b).

Panhandle Eastern's gasification plant and the Dave Johnston and Wyodak power plants would all emit particulates, and oxides of sulfur and nitrogen (SO_x and NO_x). Predicted emissions for the gasification plant were taken from its environmental report on file at the Bureau of Land Management district office in Casper (SERNCO 1974). Emissions from the Wyodak coal-fired power plant were taken from the file kept by the Wyoming Department of Environmental Quality (Wyoming Department of Environmental Quality 1978). Pacific Power and

TABLE R4-1

PARTICULATE EMISSIONS (TONS/YEAR) FROM REGIONAL MINING

Mine	Year 1980	1985	1990
Coal Mines			
Buckskin	763	1,176	1,276
Rawhide	1,596	2,026	2,218
Eagle Butte	2,077	3,222	3,096
East Gillette	1,670	1,531	1,492
Kerr McGee #16	765	1,200	1,240
Wyodak	406	434	682
Caballo	606	1,598	3,651
Belle Ayr	5,024	4,289	4,520
Pronghorn	801	1,628	1,769
Cordero	10,448	9,241	9,241
Coal Creek	1,481	3,432	3,432
Jacobs Ranch	2,431	2,754	3,149
Black Thunder	3,717	4,743	3,744
Dave Johnston	1,356	1,068	961
Rochelle	0	2,428	2,318
Uranium Mines			
Highland	1,763	2,655	3,425
Bear Creek	854	890	885
Morton	883	1,635	1,770
Bill Smith	854	910	910
Potential Mine		855	890
Potential Mine			855

Light Company, owners of the Dave Johnston Power Plant, provided the emission and stack parameters for their plant (personal communication, Horace Sanders 1978). The emissions for the Dave Johnston and Wyodak power plants and the coal gasification plant are listed in Table R4-2.

The five urban areas—Gillette, Moorcroft, Douglas, Glenrock, and Casper—are anticipated to have a significant effect on regional air quality for TSP, sulfur dioxide (SO_2), and nitrogen dioxide (NO_2). Current emissions for these pollutants were taken from the National Emissions Data System Inventory for 1977 (U.S. Environmental Protection Agency 1977). The total pollutant emissions of Campbell, Converse, Natrona, and Crook counties were apportioned to the five urban areas based on the percentage of the county population in each urban area. The 1980, 1985, and 1990 emissions from the urban areas were forecasted to increase in direct proportion to projected growth of the populations of the urban areas between 1978 and 1990. The population projections for the five urban areas are shown in Table R4-3. The TSP, SO_2, and NO_2 emissions from the urban areas are listed in Table R4-2.

The air quality impact of vehicle emissions would be highly variable, intermittent, and generally confined to the immediate vicinity of the roads. Hence, the vehicular emissions were not included in the dispersion modeling.

Oil and gas activity is expected to increase by less than 3% above existing levels by 1990 in the region. Hence, significant change in the air quality impact of oil and gas production is not expected during the study period.

Other developments in the region include construction of transmission and railroad lines. A 59-mile transmission line south from the Wyodak Power Plant and a 28-mile transmission line north from the Dave Johnston Power Plant are to be constructed to meet near the Converse-Campbell county line. Construction of these transmission lines should be short term and have a minor impact on TSP concentrations in the region. Several railroad lines are to be constructed, including the 113-mile main line between Gillette and Douglas, a 40-mile private line for transportation of coal to the planned gasification plant, and several rail spurs and sidings to serve developing mining areas. During construction, small, temporary fugitive dust sources would occur at the construction sites. The main line is anticipated to be completed by the early 1980s. The private line from the Rochelle Mine to the Panhandle Eastern Gasification Plant should also be completed in the early 1980s. Construction of these lines would not have a regional impact, because emissions would affect small areas and would be temporary.

Diesel locomotives operating on the railroad lines would increase emissions. These emissions would be intermittent and confined to a narrow corridor following the lines. Exact schedules of train operation do not exist, making predictions using dispersions impossible. It is expected that train operations would contribute less than 1% of the total particulate emission from the mines. Gaseous pollutant emissions would be less than one-eighth of those for all the towns and other coal-related activities. The locomotive emissions would be spread out over all railroad lines. Thus, railroad-associated emissions are expected to have little effect on regional air quality.

After construction, fugitive dust emissions from the transmission lines and the railroad rights-of-way would have a negligible impact on the regional TSP concentrations. Hence, these projects were not modeled for the air quality analysis.

Modeling Procedures

The annual average SO_2, NO_2, and TSP concentrations were predicted with a model based on the steady-state Gaussian dispersion equation presented in the *Workbook of Atmospheric* Diffusion *Estimates* (Turner 1972). Statistical meteorological data constructed from observations taken at the National Weather Service station in Moorcroft, Wyoming for 1950-1954 and Casper, Wyoming for 1970-1974 was input to the dispersion model. The modeling procedure for predicting annual pollutant concentrations from the mine and the urban areas is described in the technical report for Chapter 4 of the Regional Environmental Statement, available at the Bureau of Land Management Casper District Office.

The 24-hour and 3-hour pollutant TSP and SO_2 concentrations in the towns were estimated from predicted annual concentrations using Larsen statistics (Larsen 1971). All emissions of sulfur oxides were assumed to be sulfur dioxide (SO_2). All nitrogen oxides emitted to the atmosphere were assumed to be converted to nitrogen dioxide (NO_2).

Air Quality Impacts Resulting from Cumulative Regional Development

Predicted annual TSP concentrations are shown on Figures R4-1, R4-2, and R4-3. Significant TSP concentrations would occur in the area in southeast Campbell County encompassing the Caballo, Belle Ayr, Pronghorn, Cordero, and Coal Creek mines. The area is a strip 22 miles long and approximately 2½ miles wide. In this area annual TSP concentration would be 30 micrograms per cubic meter ($\mu g/m^3$), which is only 6 $\mu g/m^3$ above the rural background concentration. Concentrations would reach 35 $\mu g/m^3$ in the area between mines situated close to one another. The increase in TSP concentration would drop to 1 $\mu g/m^3$ 10 miles away from any of the mines. The annual and 24-hour Wyoming air quality standards of 60 $\mu g/m^3$ and 150 $\mu g/m^3$ may be exceeded at the boundary of some of the existing mines.

Emissions due to Gillette's population growth and interactions with the Rawhide and Eagle Butte mines (north of Gillette) are expected to produce annual TSP concentrations of 31 $\mu g/m^3$. This impact is confined to the area containing Gillette and the two mines. Concentrations nearer to Gillette are expected to reach 35 $\mu g/m^3$ in 1985 and 40 $\mu g/m^3$ in 1990. The highest 24-hour TSP concentrations are expected to occur in Gillette. A 24-hour concentration of 119 $\mu g/m^3$ is predicted in 1985 and 136 $\mu g/m^3$ in 1990. It is possible that Wyoming's 24-

TABLE R4-2
EMISSIONS OF PARTICULATES, SO_x, AND NO_x FROM OTHER
COAL-RELATED ACTIVITIES AND URBAN AREAS (TONS/YEAR)

Source	Pollutant	1980	Year 1985	1990
Coal-Related Activities				
Wyodak Power Plant	Particulates	1,755	1,755	1,755
	SO_x	14,100	14,100	14,100
	NO_x	11,227	11,227	11,227
Dave Johnston Power Plant	Particulates	18,542	18,542	18,542
	SO_x	19,637	19,637	19,637
	NO_x	19,053	19,053	19,063
Panhandle Eastern Coal Gasification Plant	Particulates		1,376	1,376
	SO_x		11,884	11,884
	NO_x		13,667	13,667
Urban Areas				
Gillette	Particulates	248	380	482
	SO_x	263	402	511
	NO_x	1,434	2,179	2,778
Moorcroft	Particulates	51	80	99
	SO_x	44	69	84
	NO_x	252	402	489
Glenrock	Particulates	62	102	91
	SO_x	47	73	73
	NO_x	328	500	507
Douglas	Particulates	124	274	241
	SO_x	99	219	193
	NO_x	686	1,500	1,325
Casper	Particulates	2,146	2,493	2,905
	SO_x	2,358	2,745	3,190
	NO_x	6,913	8,041	9,709

TABLE R4-3

PROJECTED POPULATIONS FOR CITIES IN AND NEAR THE REGION

Urban Area	Year			
	1978*	1980	1985	1990
Gillette	4,619	6,402	9,287	11,542
Moorcroft	828	1,142	1,623	1,773
Douglas	535	804	5,207	3,102
Glenrock	322	381	1,050	1,020
Casper	3,146	4,267	7,471	10,645

Note: Probable future development includes the site-specific action, existing coal-related activities, and municipal development.

* Present (base) population.

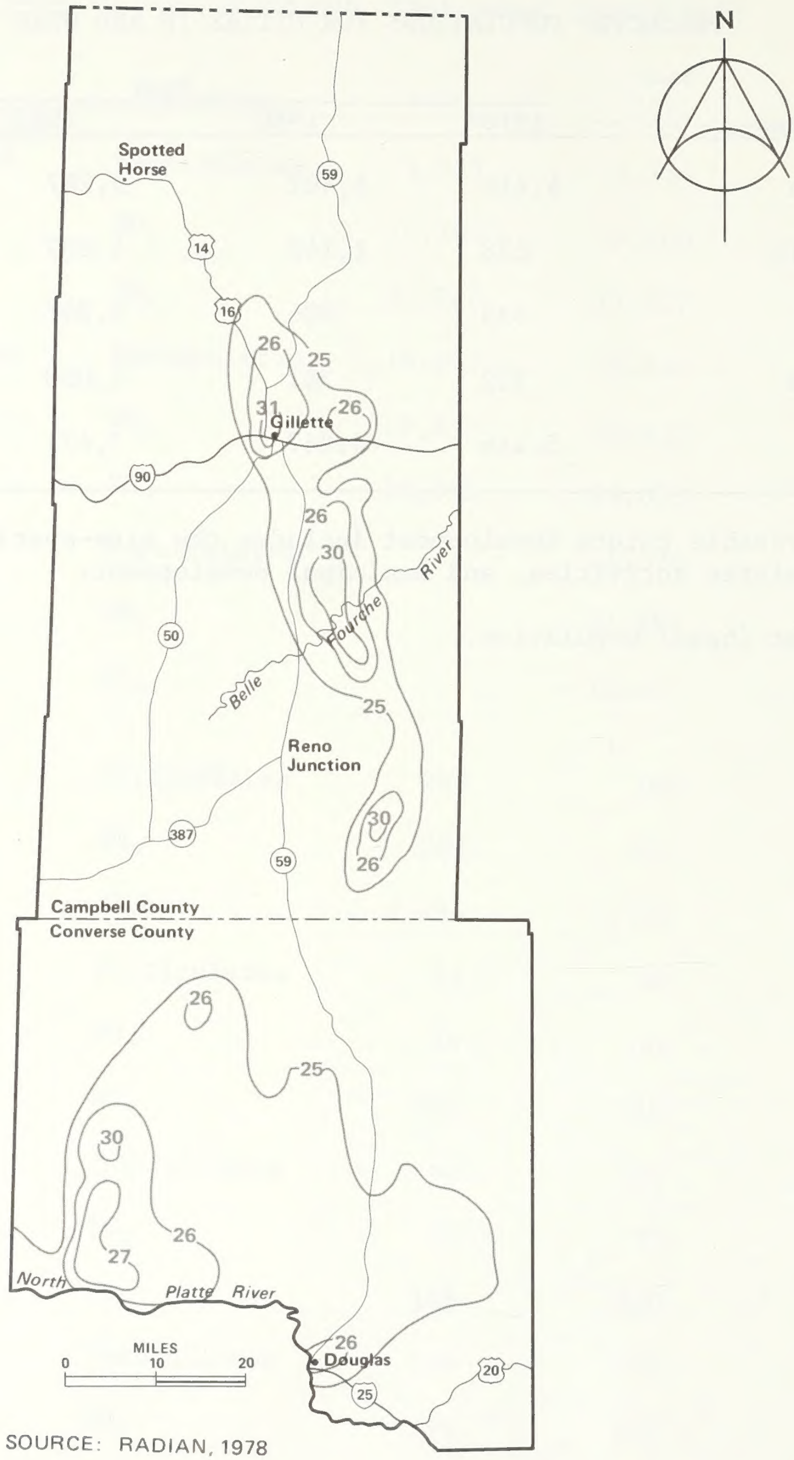
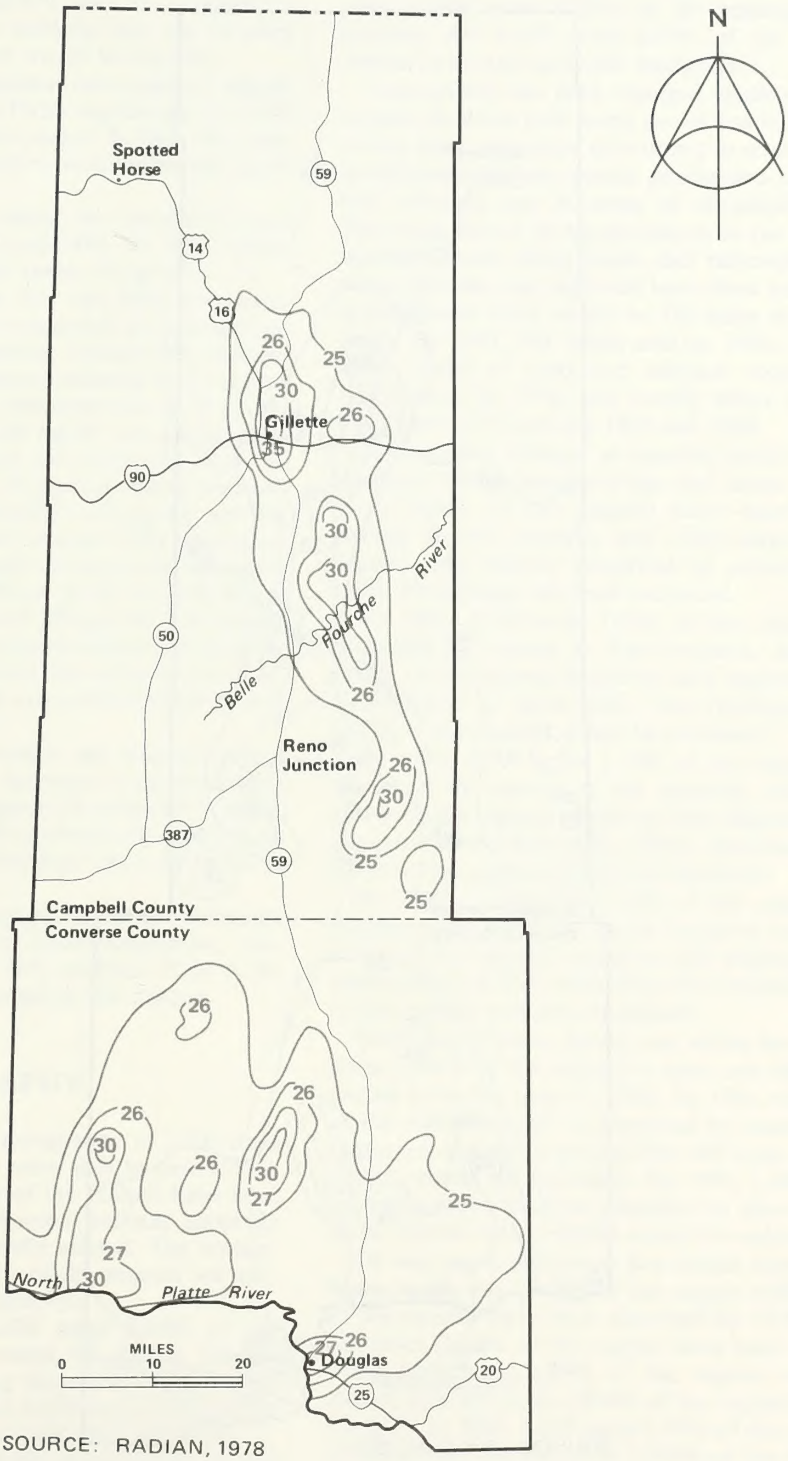


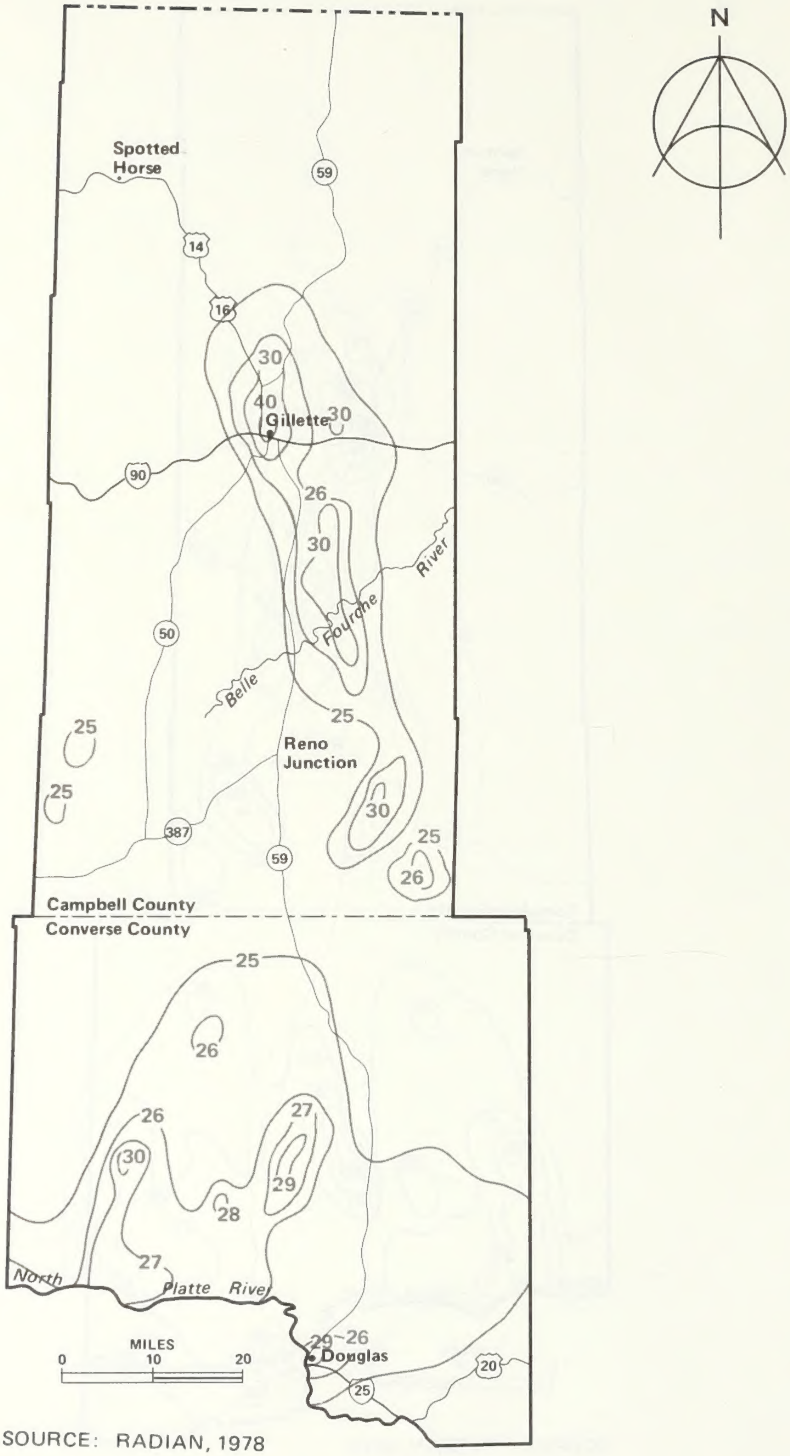
Figure R4-1
PREDICTED AMBIENT TSP CONCENTRATIONS ($\mu g/m^3$)
FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1980



SOURCE: RADIAN, 1978

Figure R4-2

PREDICTED AMBIENT TSP CONCENTRATIONS (μg/m³) FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1985



SOURCE: RADIAN, 1978

Figure R4-3
PREDICTED AMBIENT TSP CONCENTRATIONS ($\mu g/m^3$)
FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1990

hour TSP standard (150 $\mu g/m^3$) may be violated in downtown Gillette, but it is unlikely that the national primary standard of 260 $\mu g/m^3$ would be reached.

Note that under the new national prevention of significant air quality deterioration (PSD) regulations (43 CFR 118), TSP violations would not occur. In fact, the emissions from surface mines would be well within the applicable standards.

TSP concentrations surrounding the town of Moorcroft would be small in 1980 and 1985. In 1990, Moorcroft TSP concentrations could reach 30 $\mu g/m^3$.

The annual and short-term SO_2 and NO_2 concentrations surrounding Gillette are expected to increase significantly during the study period. Annual SO_2 concentrations of 8 $\mu g/m^3$ in 1980 would increase to 23 $\mu g/m^3$ in 1990. A maximum 24-hour concentration of 78 $\mu g/m^3$ and 3-hour concentration of 129 $\mu g/m^3$ are predicted to occur in 1990. Although these are relatively large increases they are all below the Wyoming annual standard of 60 $\mu g/m^3$, the 24-hour standard of 260 $\mu g/m^3$, and the 3-hour standard of 1,300 $\mu g/m^3$. Annual NO_2 concentrations surrounding Gillette would increase from 40 $\mu g/m^3$ in 1980 to 50 $\mu g/m^3$ in 1990. These levels are well below the federal and state standards of 100 $\mu g/m^3$. The annual and short-term NO_2 and SO_2 concentrations surrounding Moorcroft would be small during the study period. Predicted annual gaseous pollutant concentrations are shown on Figures R4-4 through R4-9.

Away from the town and mines, the average annual horizontal visibility related to atmospheric particulates is expected to remain near the regional baseline of 54 miles. The annual visibilities related to atmospheric particulates in Gillette are estimated to decrease from 28 miles in 1980 to 22 miles in 1990.

The Chapter 4 Technical Report, on file at the Casper District Office of the Bureau of Land Mangement, contains additional TSP, SO_2, and NO_2 analyses of the probable level of development discussed in this chapter.

TOPOGRAPHY

Coal mining has altered the topography of 2,700 acres (.05% of the region) at eleven mine sites to date (1978). Of this area, 1,301 acres (.02% of the region) have been reclaimed to a more gentle, smoother surface, generally 10 to 40 feet lower than originally existed. The remaining 1,399 disturbed acres (.03% of the region) are currently in pit and spoil pile topography.

By 1980, topography of 4,733 acres (.09% of the region) at fifteen mine sites would be altered. Of this area, 3,495 acres at the existing mine sites (.07% of the region) would be reclaimed, and 1,238 acres (.02% of the region) would remain in pit and spoil pile topography.

By 1985, topography of 12,934 acres (.26% of the region) at fifteen mine sites altered. Of this area, 9,887 acres (.20% of the region) would be reclaimed, and 3,047 acres (.06% of the region) would remain in pit and spoil pile topography.

By 1990, topography of 19,106 acres (.39% of the region) at fifteen mine sites would be altered. Of this area, 12,666 acres (.25% of the region) would be reclaimed, and 6,140 acres (.13% of the region) would remain in pit and spoil pile topography.

Topography has been changed slightly for coal mine support facilities (rail spurs, access roads, telephone lines, power lines, and mine structures), at sites of coal-related development (power plants, gasification plants, and main line railroad), and at areas of municipal development. The main impact to topography is at cut and fill sites to maintain grade along roads and railroads. By 1978, 78 miles of roads and railroads have been built. By 1980, it is anticipated there would be 195 miles of roads and railroads; by 1985, 235 miles; and by 1990, 235 miles. The above miles of road and railroad construction affect 1,539 acres in 1978; and would affect 3,987 acres by 1980, and 4,737 acres by 1985 and 1990.

Topography changes at uranium mine sites would be similar to those changes at the coal mines. In 1978, 3,000 acres (.06% of the region) have been disturbed by mining at two projects, and 1,000 acres (.02% of the region) only slightly disturbed by construction of two mills. No acreage has been reclaimed.

By 1980, 3,500 acres (.07% of the region) would be disturbed by mining at four projects, and 1,500 acres (.03% of the region) would be only slightly disturbed by construction of three mills. One thousand mined acres (.02% of the region) would be reclaimed.

By 1985, 7,500 acres (.15% of the region) would be disturbed by mining at six projects, and 2,000 acres (.04% of the region) would be only slightly disturbed by construction of four mills. Three thousand mined acres (.06% of the region) would be reclaimed.

By 1990, 11,000 acres (.22% of the region) would be disturbed by mining at seven projects, and 2,000 acres (.04% of the region) would be only slightly disturbed by construction of four mills. Fifty-five hundred acres (.11% of the region) would be reclaimed.

Quarrying of sand, gravel, and scoria has disturbed 200 acres (.004% of the region) to date, and this figure is expected to be the same by 1980. By 1985, 620 acres (.01% of the region) would be disturbed by quarrying of these resources, and it is expected that 100 acres (.002% of the region) would be reclaimed. By 1990, 1,280 acres (.02% of the region) would be disturbed by quarrying, and 300 acres (.006% of the region) would be reclaimed.

Oil and gas development has caused only slight disturbance to the topography of the region; 4,800 acres (.09% of the region) have been disturbed by 1978, and of this, 400 acres (.008% of the region) have been reclaimed. By 1980, 4,880 acres (.09% of the region) would be disturbed, and 400 acres (.008% of the region) would be reclaimed; by 1985, 5,110 acres (.10% of the region) would be disturbed, and 450 acres (.009% of the region) would be reclaimed; and by 1990, 5,250 acres (.10% of the region) would be disturbed, and 500 acres (.01% of the region) would be reclaimed.

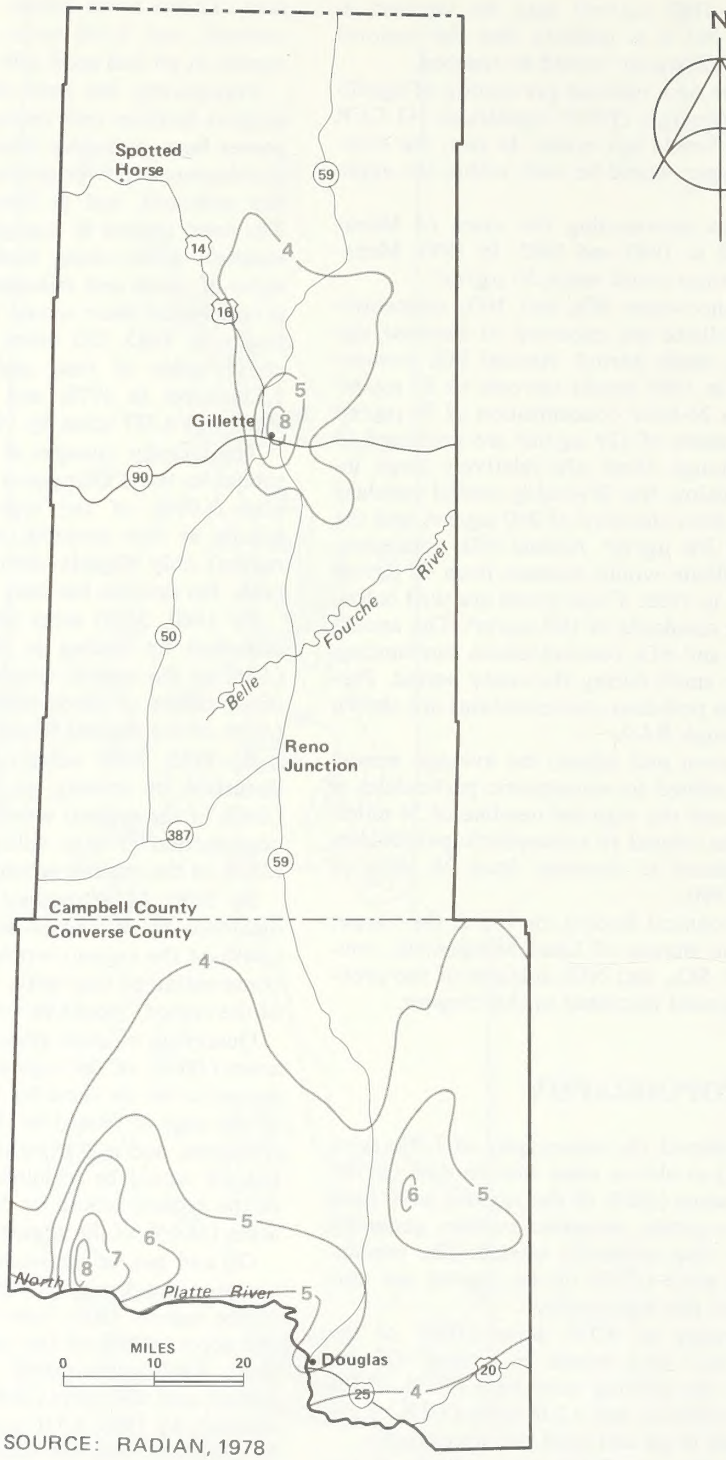
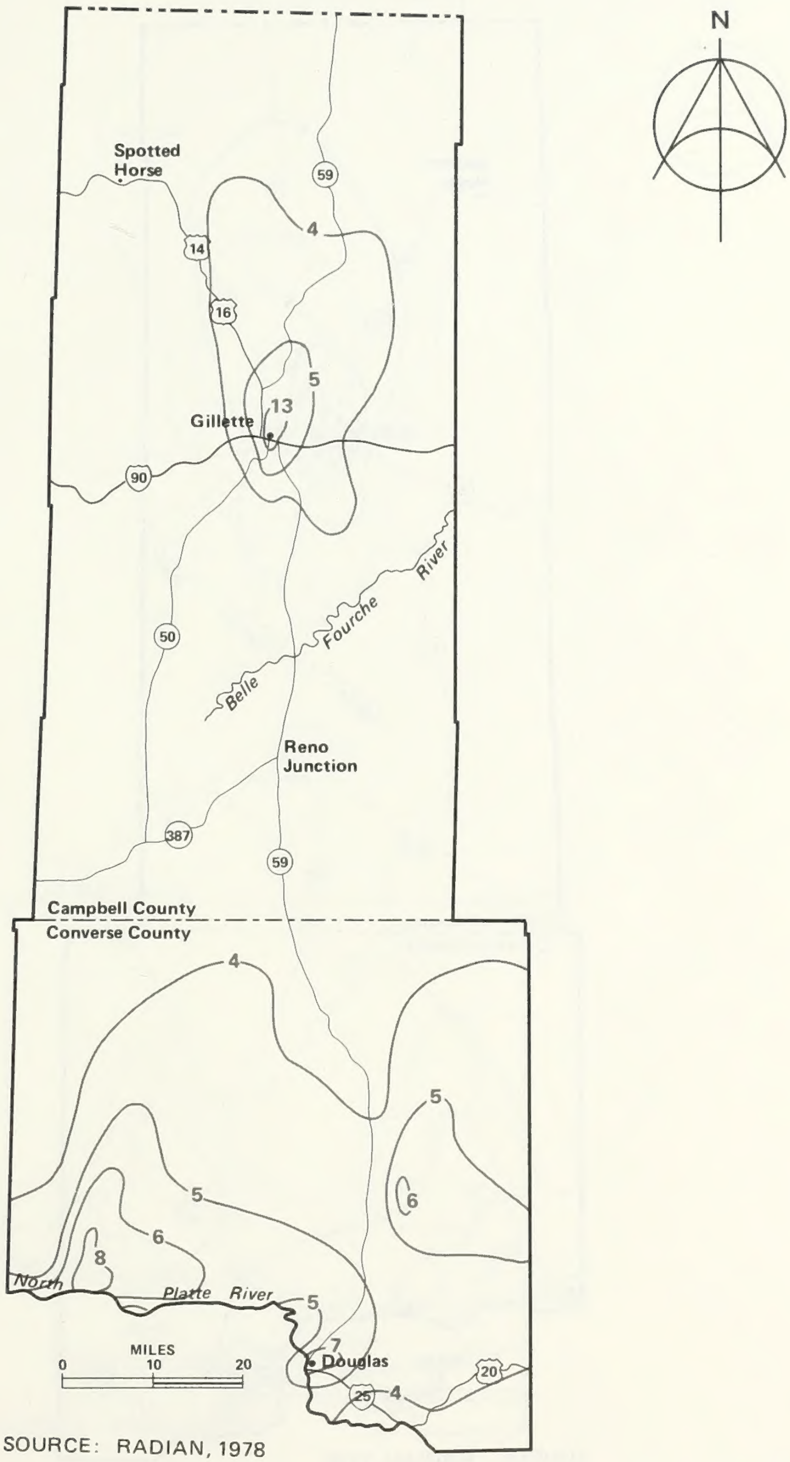


Figure R4-4

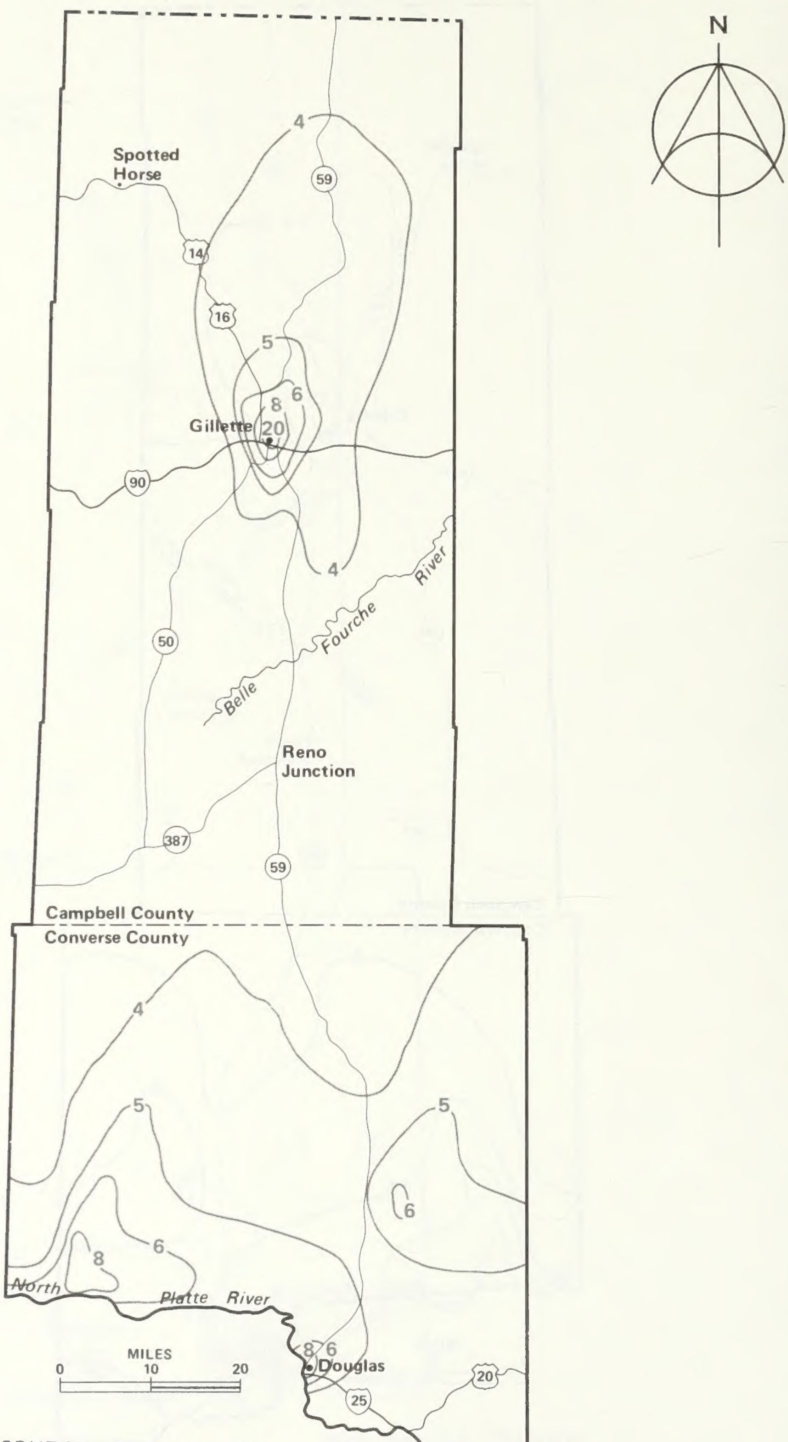
PREDICTED AMBIENT SO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1980



SOURCE: RADIAN, 1978

Figure R4-5

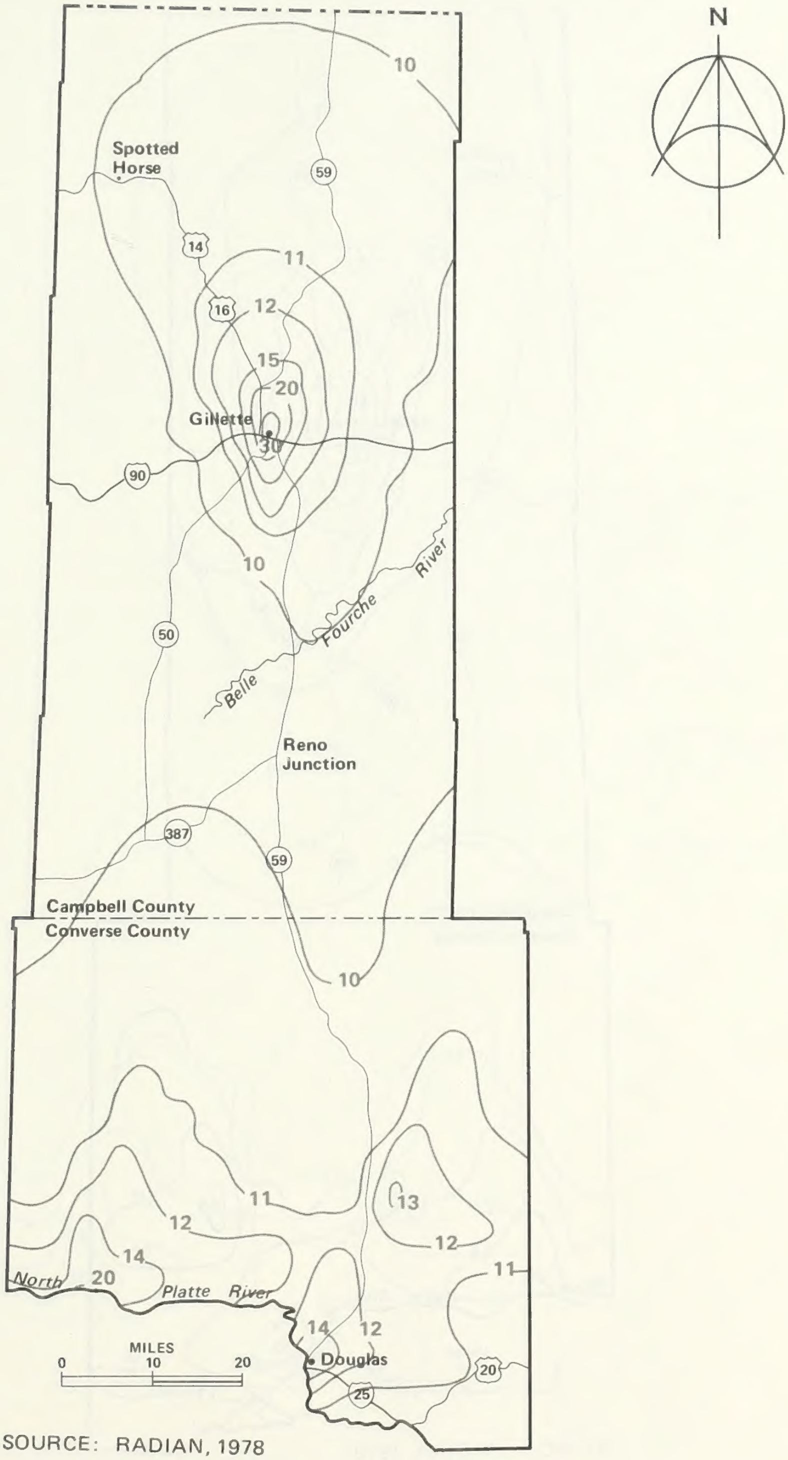
PREDICTED AMBIENT SO_2 CONCENTRATIONS ($\mu g/m^3$)
FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1985



SOURCE: RADIAN, 1978

Figure R4-6

PREDICTED AMBIENT SO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1990



SOURCE: RADIAN, 1978

Figure R4-7
PREDICTED AMBIENT NO_2 CONCENTRATIONS (μg/m^3)
FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1980

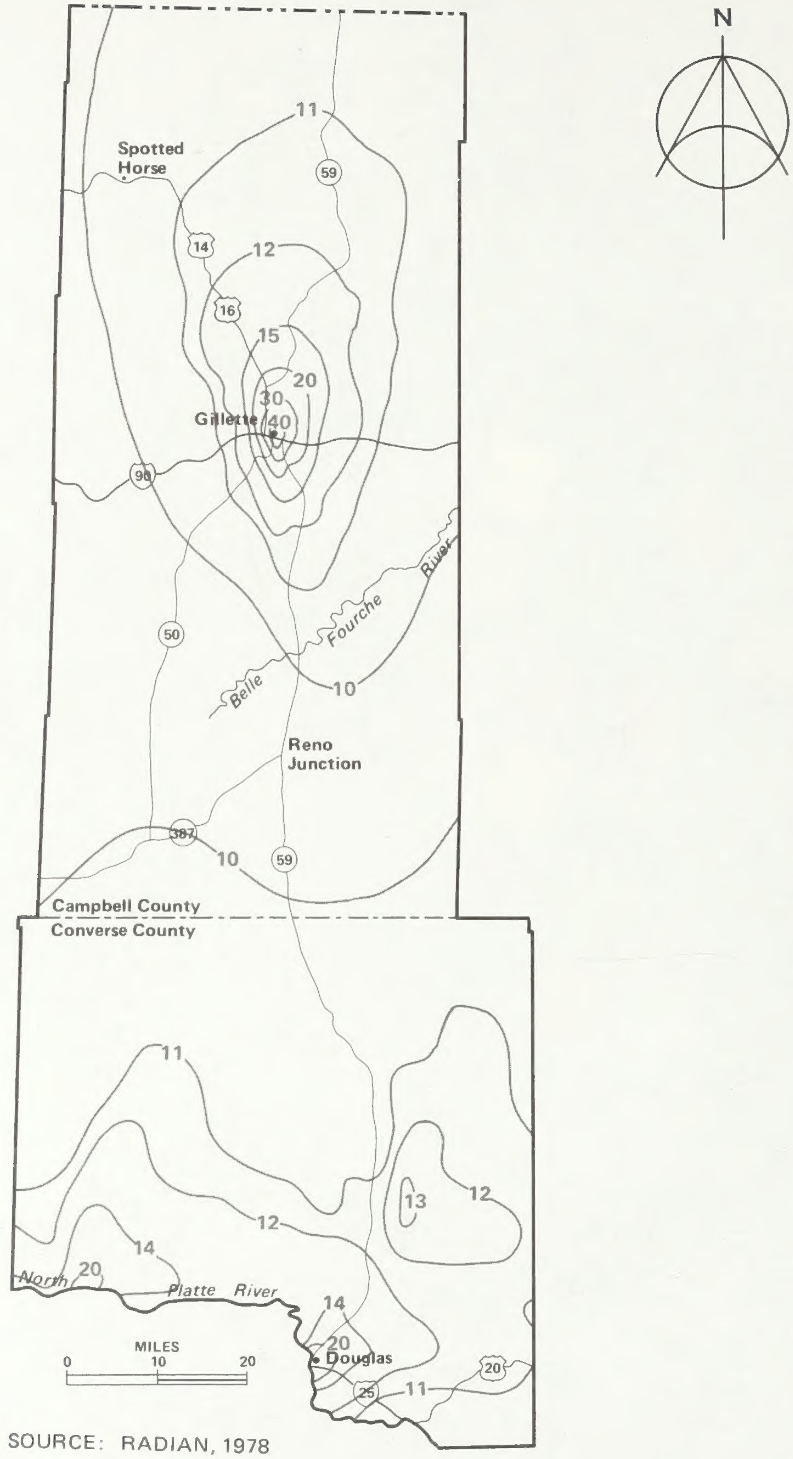


Figure R4-8
PREDICTED AMBIENT NO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1985

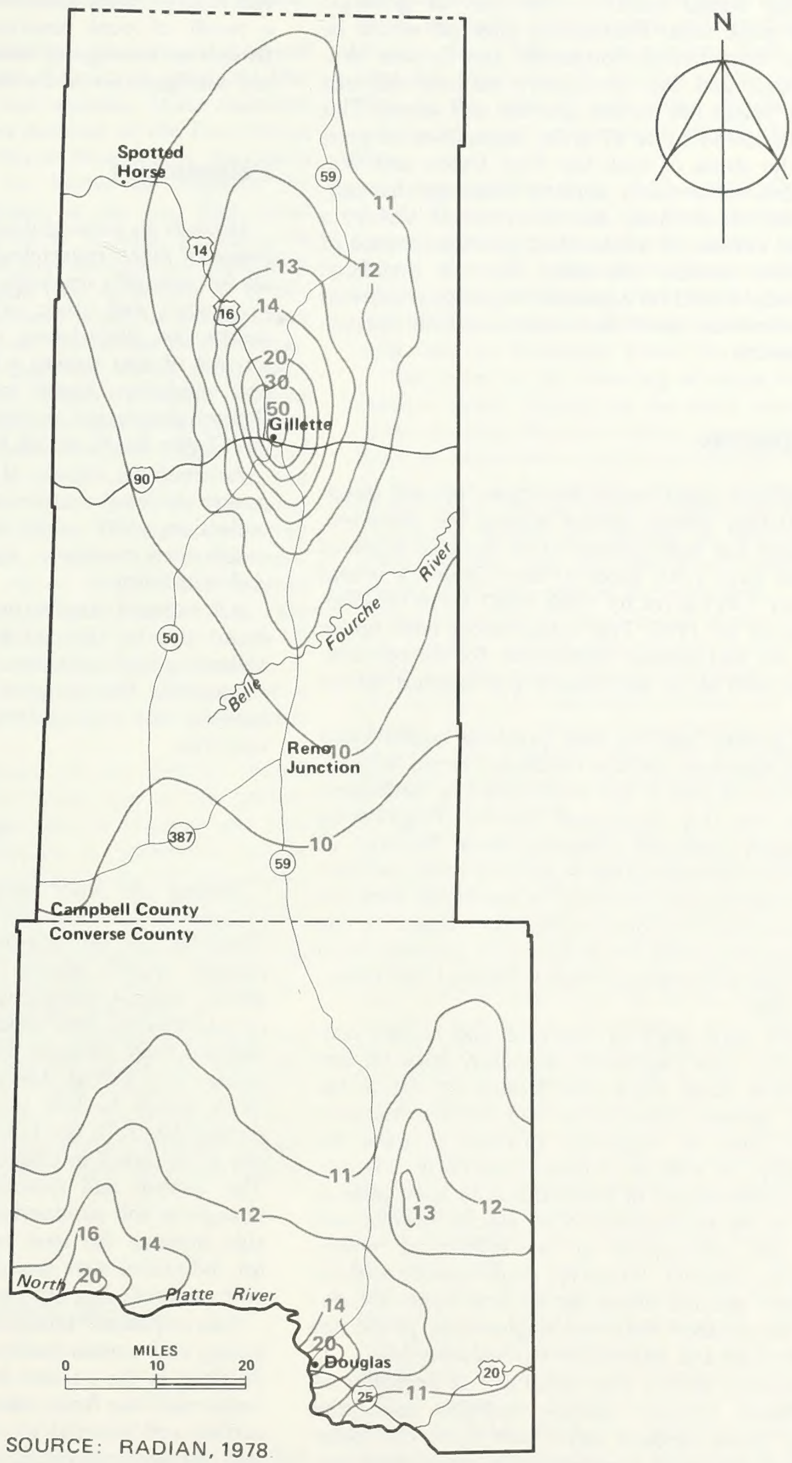


Figure R4-9

PREDICTED AMBIENT NO_2 CONCENTRATIONS ($\mu g/m^3$)
FOR THE PROBABLE LEVEL OF DEVELOPMENT IN 1990

GEOLOGY

Strip mining would result in the loss of geologic record at the mine sites. Formations affected would be the Paleocene Fort Union Formation; the Eocene Wasatch Formation; and the Quaternary surficial deposits including soil, valley fill, terrace gravels, and scoria. This loss is not considered to be of great importance at present because the strata of both the Fort Union and Wasatch formations are of fairly uniform lithology throughout the Powder River Basin and there would still be a large area and volume of undisturbed geologic record of both formations outside the mine sites. A beneficial impact of mining would be exposure of geologic sections that would otherwise never have been available for scientific examination.

Geologic Hazards

Because replaced spoil settles over time, ground stability may be altered where surface mining has occurred. Ground stability has been altered to an average depth of about 150 feet over 1,301 acres to date. Stability would be altered over 3,495 acres by 1980, 9,887 acres by 1985, and 12,666 acres by 1990. This could affect both future construction on, and seismic exploration for deeper mineral resources such as oil and natural gas through the reclaimed fill.

Decreased ground stability may preclude construction of permanent structures on the reclaimed areas, depending on the way in which the overburden is reclaimed. According to the U.S Geological Survey, Engineering Geology Branch (personal communication, Richard C. Dunrud 1978), overburden that is piled in rows and leveled by bulldozer would probably be less stable than the original surface, but overburden that is returned to the pit and compacted could be as stable or possibly even more stable than the original surface. Dunrud and Osterwald (1978) state:

> The stable slope angle of fractured and jointed bedrock on strip mine highwalls ultimately may be less than the stable slope angle of a broken up pile of the same rock, because open joints and tension fractures behind the rims of highwalls provide avenues for water to flow, as well as to freeze and thaw, whereas the broken counterpart of the bedrock in spoil piles at the angle of repose appears to be less permeable and therefore less susceptible to the effects of water. Graded spoil material, however, might absorb surface water readily and fail unless the graded slopes are designed in accordance with soil engineering properties of the broken up and mixed overburden material.

Ground stability at any one mine site is probably of little importance, because surface facilities connected with mining would already have been built on undisturbed ground, and spoil areas would be reclaimed primarily for grazing and wildlife habitat. Sites for future seismic exploration could be located outside the reclaimed areas. However, as mining progresses in the region, an area of altered stability to an average depth of about 150 (60 to more than 400) feet could develop along the area of coal outcrop, a strip about 1 to 12 (generally less than 6) miles wide and more than 100 miles long. As a result of coal removal, this area would become a trough an average of about 50 feet lower than the present configuration of the land.

Paleontology

Impacts to paleontological resources would consist of losses of plant, invertebrate, and vertebrate fossil materials for scientific research, public education (interpretative programs), and other values. Losses would result from destruction, disturbance, or removal of fossil materials as a result of coal mining activities, unauthorized collection, and vandalism. Fossil materials of Quaternary through Pennsylvanian age occurring in a number of formations (see Table R2-6) would be impacted to variable degrees.

A beneficial impact of development would be the exposure of fossil materials for scientific examination and collection which might never occur except as a result of overburden clearance, exposure of rock strata, and mineral excavation.

All exposed fossilferous formations within the region could also be affected by increased unauthorized fossil collecting and vandalism as a result of increased regional population. The extent of this impact cannot be presently assessed due to a general lack of specific data on such activities.

SOILS

Mining and other activities would impact soils by alteration of existing soil characteristics and properties. These include soil microorganism composition, structure, texture, organic matter content, infiltration rate, permeability, water-holding capacity, nutrient level, soil-climatic relationship, and productivity, all of which have developed over geologic time (U.S. Department of the Interior 1975, 1976a). The established levels of soil productivity would be lost and probably not fully recover to present levels in the long-term (based on analysis of one site as discussed in Chapter 3 of the site-specific analysis). The quality and quantity of "topsoiling" material and change in soil productivity after reclamation is quantifiable through the land capability and range site systems for individual sites (see Chapter 3, Soils, of the site-specific analysis), but not on a regional basis.

The exposure, compaction, burial, stockpiling, disturbance, and contamination of surface soil would cause reductions in the current levels of soil productivity and increase soil loss from wind and water erosion. Stockpiling surface soil material would degrade biological, chemical, and physical properties, causing reductions in productivity when used in reclamation (ibid., Monsen 1975). Accidental spills of oil, gasoline, and other toxic materials could contaminate and sterilize the soil horizons, rendering the affected soil unusable for reclamation, but such accidents would be localized and of little relative significance. Any such contaminated material would be buried

as required by the Surface Mining Control and Reclamation Act (SMCRA).

Mining could expose material which contains chemical constituents (such as selenium, boron, or uranium) that would be harmful to plants and animals. These materials could exist in the overburden material of the Fort Union Formation (see Chapter 2, Water Resources). Any such material identified would be buried as required by SMCRA. Other materials found in the area that could hamper reclamation include those of high alkalinity or salinity, sand or clay-textured material, and material with low cation-exchange capacities (see Appendix B, Soils).

All of the regional development activities would result in accelerated erosion by wind and water due to exposure and increased activity, until the soil is revegetated (Monsen 1975). Wind action, which is fairly constant over the area, would cause fine particles to be lifted from the exposed surfaces and blown away (see Chapter 4, Air Quality). Prior to revegetation of exposed, disturbed, and stockpiled soils, high intensity storms (possibly occurring about 1 year in 10 years to 1 year in 25 years), occurring mainly in late May or June, could lead to increased water erosion (Becker and Alyea 1964). The increased erosion would result from the disturbed soils not having any protective cover and inability of the soil to soak up the water. Such losses are not possible to quantify. A range of soil loss due to erosion can be estimated on a site-specific basis (see Chapter 3, Soils, of the site-specific anaylsis).

Future population increases in the region would impact the soil resource. Permanent loss of soil surface would result from the construction of housing and support facilities. Also, the increase in population would result in greater use of the region's soils for recreation, particularly by off-road vehicle users. Greater off-road vehicle use would result in increased soil compaction in the localized area of use and an accelerated rate of soil erosion. The loss in the soil resource as a result of increased off-road vehicle use is nonquantifiable.

For a summary of cumulative acreage disturbed and reclaimed by coal mining activity under the probable level of development, refer to Table R1-5 in Chapter 1.

For a summary of cumulative acreage disturbed and reclaimed by all regional development activities under the probable level of development, refer to Table R1-6 in Chapter 1.

WATER RESOURCES

Groundwater

The water levels in lateral equivalents of the aquifers destroyed by coal mining would be lowered. Figure R4-10 shows the potentiometric surface in the Wyodak coal as it probably existed when only the Wyodak Mine was in operation. The depression in the vicinity of the mine is graded to the base of the mine pit which is at an elevation of about 4,300 feet, about 100 feet lower than the surrounding terrain. There are now nine mines in operation, or under construction, and six more may be in operation by 1990. A depression, such as that at the Wyodak Mine, would develop in the potentiometric surface in the coal at each mine except Dave Johnston, where the coal reportedly is above the zone of saturation.

In the southern part of Campbell County this would result in local reversal in flow; recharge areas would become discharge areas. In the central part of the county where there is a trough in the potentiometric surface which trends northward, flow would be permanently disrupted. The area near Gillette would remain a discharge area, but the discharge would be focused at the mines.

The extent of the lowering of water levels in the overburden would depend on the areal extent and thickness of the aquifers. Because of the presence of shale, the base level to which the overburden aquifers will drain would be the base of the aquifer, and not necessarily the bottom of the mine. Where these aquifers are truly water table, drawdown would not exceed the thickness of the individual aquifer and the drawdown would approach the aquifer thickness only at the mine face.

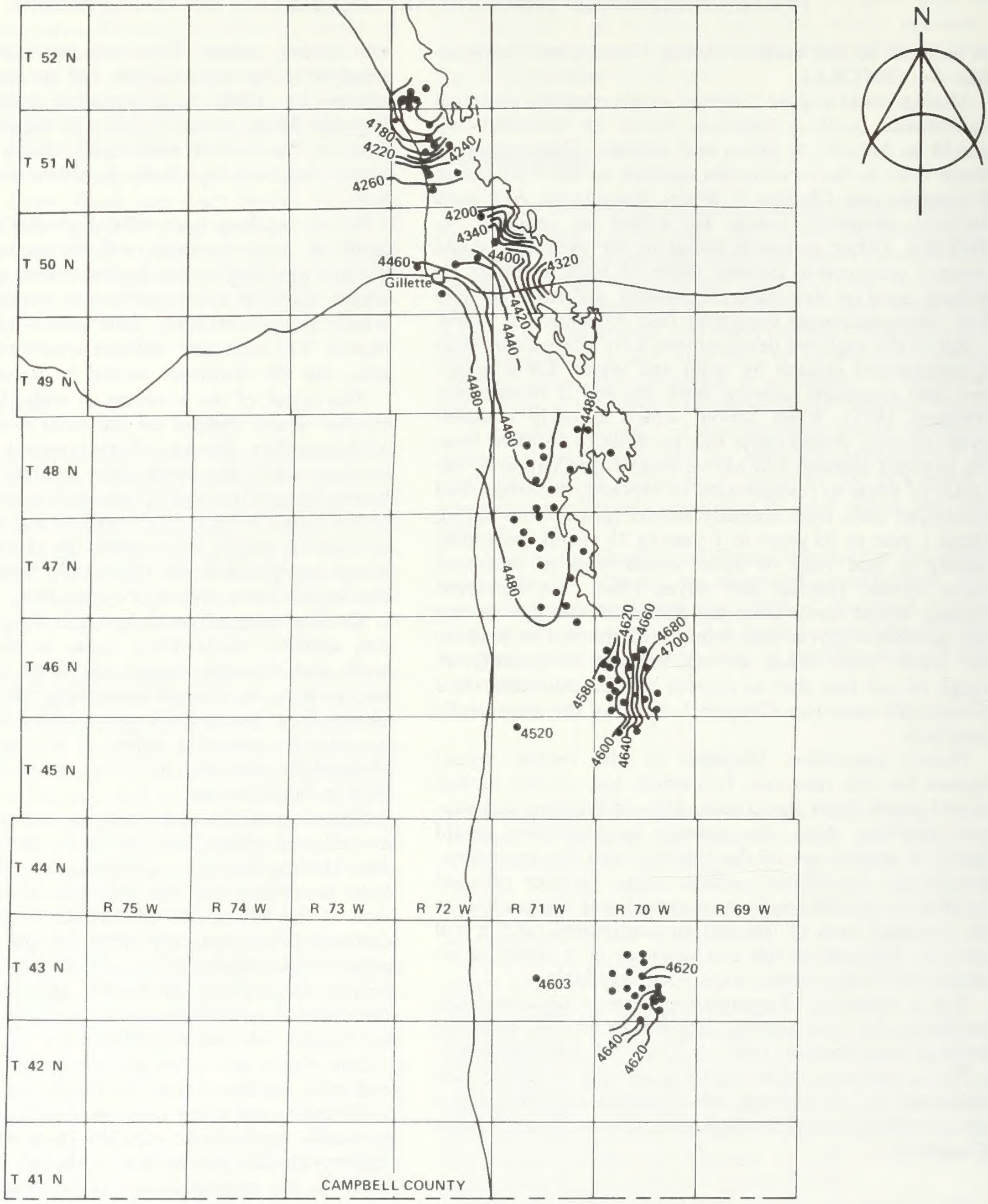
The lowering of water levels in the coal and overburden aquifers would affect water levels in some nearby wells and decrease natural discharge which is by seeps and springs, by evapotranspiration, and to streams. Discharge from the bedrock, overburden, and coal may also be into the alluvium where it is evapotranspired, discharged into streams, or moves out of the area as underflow in the alluvium.

Stripping of alluvium that has been determined to be an "alluvial valley floor"under the definition of the Surface Mining Control and Reclamation Act of 1977 would have to comply with the standards of the act. One provision of the act is that disturbance to the prevailing hydrologic balance at each mine site and associated offsite areas will be minimized by, among other measures, "preserving throughout the mining and reclamation process the essential hydrologic functions of alluvial valley floors in the arid and semiarid areas of the country"

The impact of lowering water levels in the overburden and coal aquifers would be minor. Stock and domestic wells basinward a few miles perpendicular to the outcrop generally tap bedrock aquifers in stratigraphic horizons higher than the overburden. Although lowering of water levels in the aquifers closer to the mines is anticipated to be small, where wells are adversely impacted, the impacts can be mitigated by deepening the wells.

Water levels would be lowered in aquifers below the coal because of development for plant requirements and additional development for municipal supplies.

The acreage reclaimed during successive periods is shown in Table R1-6. The extent to which the reclaimed spoil would be saturated is not known; however, a study by Rahn (1976) indicates that the spoil is potentially able to transmit water nearly as well as the aquifers it replaces. Water in the spoil would be under water-table conditions; further, the plans submitted for postmining topography of some mines show the land surface, at least in part, lower than the original potentiometric surface.



• WELL COMPLETED IN THE WYODAK COAL SEAM

—4620— ELEVATION OF GROUNDWATER SURFACE IN THE WYODAK COAL SEAM

EASTERN EDGE OF THE WYODAK COAL SEAM (CENTRAL REGION) ADAPTED FROM DENSON AND KEEFER, 1974

Figure R4-10

WATER LEVELS IN THE WYODAK COAL SEAM IN CENTRAL AND SOUTHERN CAMPBELL COUNTY, WYOMING

Therefore, the original groundwater movement would not be restored by reclamation.

In recharge areas, the quality of water in the spoil would be similar to that described for the alluvium in Chapter 2 and would be poorer than the quality that occurred in some of the destroyed aquifers. However, because the chemical environment would not be changed in the adjoining aquifers, water moving from the spoil into adjoining aquifers would undergo reactions described in Chapter 2 such that dissolved common ions and trace elements in the water a short distance from the mine would be the same as before mining.

In areas where bedrock aquifers discharge into spoil, the water moving into the spoil would probably increase somewhat in dissolved constituents.

One coal gasification plant is projected to be in operation by 1990. The plant would require about 7,000 acre-feet of water annually, and the water sources being considered include the Madison Limestone, the Lance Formation, and the Fox Hills Sandstone. Until the quantity and source of groundwater that would be used is known, no estimate of impacts on supply can be made. Further, other environmental impacts cannot be assessed without a description of what by-products, if any, would be allowed to enter into the hydrological system.

The impacts of uranium mining, particularly with regard to potential hazard to quality of groundwater, require additional study. However, in the southern part of the region, which is the principal uranium area, the sandstone aquifers are apparently better aquifers than those to the north. Ranchers have reported mining and milling operations have adversely impacted some stream reaches with perennial flow and have caused at least one well to cease flowing.

Changes already occurring in the regional groundwater system are discussed further in Chapter 8, Low-Level Scenario.

Surface Water

Large areas mined within the region as of 1978 are depleted of point-watering sources for stock and wildlife amounting to about 8 square miles (5,323 acres) for coal-related activity and about 26 square miles (16,869 acres) for coal plus other development activity. These areas would be increased as indicated in Tables R1-5 and R1-6 of Chapter 1. These tables also show estimated reclaimed areas. Of the presently disturbed areas, approximately 75% of coal-related disturbed areas (4,022 acres) and approximately 90% of coal-related plus other disturbed areas (15,168 acres) are unreclaimed. This leaves large areas susceptible to erosion and to contamination of surface water from the mine spoil leachate and mine effluent during the life of the mines and their reclamation.

Mining would eliminate the present subsurface ground structure under the drainages of streams which flow parts of most years. These streams provide many point-watering sources, shade trees, and forage for stock and wildlife during part or all of most years. Although this flow is insignificant in its total volume, and normally succumbs to evapotranspiration not far from its appearance in the stream, it is very important if the area is to be reclaimed to its former use of stock ranching. Table R4-4 is an attempt to estimate the possible loss of wet stream, pond, and shallow well, point-water sources.

Impacts due to the interception by mining operations of drainages (estimated from about 650 square miles now to about 1,100 square miles by 1990) are difficult to evaluate; most of this drainage would be bypassed in temporary channels around or through the mines. Since the designs of these channels must normally provide for a large flood (from a storm return period greater than 100 years) before they are approved by the State Engineer (personal communication, Paul Thompson 1977), there should be little chance of an adverse impact from floods. If a major flood beyond the design capacity of the bypass channels or detention structures should occur, an increased sediment and chemical contaminant load might occur if not intercepted by the mine pit. Data are insufficient to quantify any such occurrence.

Mine effluent would most likely average less than a half of a cubic foot per second (cfs) per mine, much of which would be used for dust suppression. The water used for dust control would evaporate, leaving a residue of salts, trace metals, and other contaminants on the surface of roads and in ditches. It may later escape from the mine area as drainage patterns change during mining. Water pumped into evaporation or storage ponds would concentrate contaminants with time, causing the ponds to become sinks of very high concentration. Overtopping of these ponds by flooding could cause contaminant drainage out of the mine area. Data are not available to quantify this contaminant accumulation.

Most investigators of the chemical quality of water in spoil of rehabilitated coal mine areas agree that this water (source of surface water) is more highly mineralized than the groundwater in undisturbed formations. They are also in agreement that the greatest pollution impact might be due to a possible increase in the concentration of heavy metals. Some are toxic to plants and animals even at low concentrations.

Table R4-5 shows: that the coal and overburden leachates are greater in heavy metal concentration than the natural surface waters in almost all cases; that the concentration of heavy metals in the soil is a potentially large source of supply; and that dissolved concentrations already in the surface water almost exceed public water supply standards. Heavy metal concentration from the mine leachate exceeds recommended maximum concentration for irrigation on a continuous basis, livestock use, public water supply, and aquatic biota. For this reason, reclamation efforts must attempt to trap all leachate and intercepted surface flows from small drainages within the mine areas. Flows which escape the mining areas carrying the heavy metal contaminants would expose forage and crops to these contaminants. Repeated irrigation by such water could increase concentration in plants to the point that growth could become stunted. The greatest hazard, however, might be the place in the food chain of such plants. Stock and humans eating the contaminated plants and crops would in turn be accumulating these

TABLE R4-4

IMPACTS TO SURFACE WATER AT PROBABLE LEVEL OF PRODUCTION

Impacts	1978 All Activity**	1980 All Activity**	1985 All Activity**	1990 All Activity**	Long Term* All Activity**
Estimated depressions in square miles (40, ± 10% will probably be fed by groundwater).	0.2 to 0.3	0.6 to 0.9	1.8 to 2.6	2.5 to 3.6	9½ to 13***
Estimated potential intercepted drainage area in square miles.	(None till end of final reclamation)				620 to 2,000
Estimated lost point-water sources:					
Ponds in acres (includes flowing wells, springs, playas, and lakes).	110	150	260	330	440
Wet streams in miles (perennial sections and wet-pothole sections).	16	23	39	49	80
Estimated potential sedimentation in acre-feet per year.	160	200	290	340	--
Total water use, cubic feet per second (see Table R1-8).	68	74	94	97	--
Water use by coal only, cubic feet per second.	1.4	3.0	4.7	4.8	--

Note: The greatest impact in the region may occur to the quality of the water. There is not enough data available to quantify this degradation; see text for qualitative analysis.

* After mining and reclamation is done.

** Includes all mines and plants and related development.

*** Estimated water loss due to evaporation = 6,400 acre-feet/year or 9 cubic feet/second.

TABLE R4-5

COMPARISON OF MAXIMUM HEAVY METAL CONCENTRATIONS IN SURFACE WATERS IN THE LITTLE POWDER, CHEYENNE, AND BELLE FOURCHE RIVERS; BLACK THUNDER MINE LEACHATES; SOILS AND SAGEBRUSH SAMPLES THROUGHOUT THE REGION; AND RECOMMENDED MAXIMUM CONCENTRATIONS FOR PROTECTION OF VARIOUS WATER USES

	Maximum Observed Concentration (ppb)[a]					Recommended Maximum Concentration for Protection of Water Uses (ppb)[a,c]				
	Surface Water[k]		Coal & Overburden Leachates[b]							
Heavy Metal	Total	Dissolved	Black Thunder Mine	Soil[c]	Sagebrush[c]	Irrigation[d] (continuous use)	Irrigation[d] (20-year use)	Livestock	Public Water Supplies	Aquatic Biota
Arsenic	55	3	90	---	---	100	2,000	200	100	1,000
Beryllium	10	10	120	1,500	---	100	500	e	f	f
Cadmium	20	3	400	30,000	---	10	50	50	10	3[g]
Copper	140	5	320	50,000	---	200	5,000	500	1,000	15[h]
Lead	200	4	10	100,000	150,000	5,000	10,000	100	10	30
Mercury	0.8	0.2	1	40	---	f	f	10	2	0.05[i]
Molybdenum	14	16	23	20,000	30,000	10	50	f	f	f
Selenium	7	7	21	---	4,800	20	20[j]	50	10	f

a Parts per billion or micrograms per liter.
b Source: University of Wyoming, Black Thunder Project Research Team 1976.
c Source: Conner, Keith, and Anderson 1976.
d Based on irrigation rate of 3 acre-feet/acre/year.
e Because of inadequate date, no maximum water quality criterion was recommended for beryllium; however, a daily dosage of 18 mg/kg body weight apparently had no adverse effects on laboratory rats.
f No recommendation given.
g Recommend 3 ppb in hard water and 0.4 ppb in soft water.
h No recommendation given, but 15-33 ppb appear to be safe for reproduction by fathead minnows in hard water.
i No recommendation for total inorganic mercury but recommend no more than 0.05 ppb average total mercury (inorganic plus organic) and 0.2 ppb total mercury at any time or place.
j Based on toxicity of forage to livestock rather than phytotoxicity.
k Source: Reports of the U.S. Geological Survey.

heavy metals. Human consumption of the contaminated animals would also add to the accumulation of heavy metal concentration in humans, possibly above the levels which might be tolerated. Data are not available to estimate the extent of this possible danger. (Total disolved mineral content of water from replaced overburden material at the Amax Belle Ayr Mine was found not greatly different from water in undisturbed overburden or coal, Davis and Rechard 1977; however, the overburden water could be higher in trace metals (confirmation through more study is needed), personal communication, Paul Rechard 1978.)

Leachate from mines from which coal is used in the gasification process should be more toxic than that from other coal mines. This is due to the fact that the ash from the processing and gasification plant would be dumped in with the mine spoil (and covered with a minimum of 6 feet of spoil). Brine and other mill waste would be mixed into the ash at the mill, concentrating many of the contaminants which were in the coal and in the processing chemicals and gases. Soluble salts amount to about 4% of the weight of the ash (SERNCO 1974).

Coal gasification plants along with electric power plants (water cooled) are the greatest industrial water consumers, each requiring about 14 cfs. (For comparison, total streamflow originating off each square mile of the region is about 260 cfs, and the total streamflow exiting over the borders of the region equals about 110 cfs.)

Only slight adverse impact due to increased erosion is anticipated with the reclamation called for in state and federal standards (see Chapter 3): reclaiming to the natural average or flatter slopes; restoring to the approximate original contour; revegetating the replaced spoil material; preserving the natural surface drainage; and returning alluvial floors to their original hydrologic function. (This includes returning floodplains and the original sinuosity of the stream beds close to the undisturbed, natural condition).

If, however, reclamation proceeds as indicated by many of the submitted mine plans, progressive differential settlement would most likely occur. This could cause reclaimed drainage patterns to shift from that planned for reclamation and could cause potholes to form. (Consolidation and shifting occurs in reclaimed spoil, Davis and Rechard 1977.) The changed tributary drainage patterns would cut new stream paths and cause gullying. (The larger channels would be replaced at the same elevation and slope as before mining whereas the tributary channels would not.) Tributary channels from unmined land to the larger channels would have steeper slopes due to lowering of part of the drainage (lowered by the amount of coal removed minus the amount of overburden swell). These changing tributary channels would probably cause headcutting, sedimentation, and loss of reclaimed land until the channels hydraulically adjust to their new ground slopes. However, potholes and depressions forming (see Table R4-4) would trap silt and surface runoff, causing decreased sedimentation and increased infiltration to the groundwater supply. Data are not available to quantify sedimentation due to these impacts.

Sedimentation impact could be greatest from the unreclaimed overburden. During the high intensity thunderstorms common to the region, large amounts of sediment from the spoil piles may find their way into the bypass channels around the mining operations, thence out of the mining area, thus providing an unnatural sediment source to be carried downstream during subsequent stream flows. Shown, Hadley, and Ringen (report in preparation) found the sediment yield from a basin containing a nonrehabilitated mine to be about eight times that from a neighboring basin. Combined with the two sediment studies mentioned in Chapter 2 which indicate an average erosion rate of about 0.8 to 0.9 acre-feet per square mile per year, a sedimentation estimate of about 7 acre-feet per square mile per year is derived for unreclaimed mining areas.

Rehabilitated or reclaimed mine spoils were studied by Lusby and Toy (1976) on two mines, the Dave Johnston Mine near the southern end of the region, and the Big Horn Mine near Sheridan. They found that streamflow runoff and sediment were generally higher on the reclaimed land than on the undisturbed land. They said that this might be attributed, however, to increased slopes, increased clay content of the surface soil, and decreased root density of the vegetal cover.

Increased water use from 1978 has been projected at about 8% to 1980, 37% to 1985, and 42% to 1990. (Coal-related water use averages only about 4% or 5% of total water use whereas oil, uranium, and coal-gasification industries account for about 50% of total water use. See tables in Chapter 1.) No material increase in irrigation, stock water, rural domestic, or oil field water use is foreseen. Water supply for coal mining has been estimated at about 1,000 acre-feet per year now, and is projected to increase by about 220% by 1980, 340% by 1985, and 350% by 1990. Increase in water use due to municipal, mining, gasification plant, and power plant needs would most likely be met locally. Considering that the surface water supply has decreased once (about 1930) since records began and may do so again, and that it is economical to store only a portion of the total runoff in reservoirs for water supply, it appears that some of the future supply must either be imported or come from the ground. (The Wyoming State Engineer (1974) indicates that there may be groundwater available for municipal and limited industrial development in northeast Wyoming; however, data are not available to confirm this.) Large-scale groundwater withdrawals could result in hydrologic depletion of flow of streams and springs, and competition for the use of water with its present users, according to the Task Committee on Groundwater Hydrology, American Society of Civil Engineers (1977). Data are insufficient to quantify the above noted depletion of surface water.

Increased sewage due to increased population is estimated on Table R1-8. Efforts would be directed toward increasing capacities of present sewage disposal plants and including adequate systems in the design of new communities such as Wright. Increased salinity and harmful bacterial contamination would probably be noted in the North Platte River (the only perennial

stream bordering or within the region). The increase, however, is not expected to be enough to endanger aquatic biota or downstream water users. Dissolved oxygen concentrations should not be lowered to dangerous levels. Sewage effluent discharged to ephemeral streams most likely would sink into the stream beds. Coliform contamination should be neutralized within a short distance downstream from the discharge points, except during periods of storm runoff; and salts accumulating in the stream beds would be flushed downstream during subsequent flows.

The greatest impact, and the longest lasting impact, to the water resource may be caused by the uranium rather than the coal-mining industry. Uranium mines plan to leave impoundments, large areas of unreclaimed acreages and deep lakes in some of the unreclaimed pits. Breakouts of abandoned impoundments and erosion from unreclaimed areas could degrade downstream flows. If the groundwater table intercepts the ground surface (as it would in the unreclaimed pits) downstream or down gradient from the spoil replaced in the pits, plants and animals could be exposed to water of poor quality containing toxic amounts of heavy metals. (Such heavy metals accumulate within the plant or animal, and dangerous levels may be reached.)

Potentially more dangerous however, especially on a long-term basis, is the possible radiological contamination from the uranium mills. Leachate in the tailings ponds is well beyond the safe limit for animals. Escape by infiltration to the water table or by breakout to stream drainages could cause contamination by dangerous levels of radioactivity. Stock or humans using water from wells down gradient from tailing ponds would be exposed. Plants and animals encountering contaminated flows or contaminated sediments deposited in drainage channels would be exposed. Increasing the danger is the nondegradable and accumulative character of this type of contamination. Plants, edible crops, and river biota accumulate and concentrate radium-226. Levels in wells near uranium mills in the Gas Hills area of Wyoming vary from less than 10 picocuries to 50 picocuries per liter. Concentrations as high as about 35 picocuries per liter have been noted in the Little Medicine Bow River in the Shirley Basin area of Wyoming. The United States Public Health Service limit for radium-226 is 3 picocuries per liter. (Sources for above are Clark and Kerr 1974, Tennessee Valley Authority 1976, and Nuclear Regulatory Commission 1977.)

VEGETATION

Under the probable level of development, all activity (coal mining, uranium mining, oil and gas activity, sand, gravel, and scoria extraction, access roads, railroads, power lines, power plants, a gasification plant, and population increases) would cumulatively disturb vegetation on 23,274 acres by 1980, 41,931 acres by 1985, and 52,803 acres by 1990. The disturbance on 18,966 acres would be reclaimed by 1990. (See Table R1-6.)

Coal mining activity alone under the probable level of development would disturb 8,421 acres by 1980, 16,622 acres by 1985, and 22,794 acres by 1990.

Table R4-6 lists the vegetation types disturbed in the region at the probable level of development.

Terrestrial Vegetation

For all development activity, the impact on vegetation would begin prior to actual extraction operations with the construction of access roads, surface facilitites, rail spurs, power lines, and the associated population increase.

The destruction of terrestrial vegetative cover would result in impacts on livestock, wildlife, recreation, aesthetics, soil, and water. Within the reclamation process, the establishment of vegetative cover has to be accomplished before satisfactory control of soil erosion, improvement of water quality, or any use of the area by man or animal is feasible.

Strip mining causes a greater impact to vegetation than to most other resources, both aesthetically and biologically. The success of vegetative rehabilitation depends upon a number of climatic and biotic factors, as well as the type of disturbance. Precipitation in the region varies from 12 inches in the southern part to 17 inches in northern Campbell County. Reclamation success is therefore expected to be more likely in the northern part of the region. In some years, climatic conditions such as droughts and sudden downpours could undo revegetation attempts. Revegetation is also dependent upon artificial restoration measures, since severely disturbed areas recover very slowly through natural regeneration. Factors which could hinder revegetation are less than ideal soil properties, steep slopes, loss of seeds, and destruction of seedlings by small mammals.

Despite such problems, successful reclamation appears to have been achieved in the region. Since the previous environmental statement on the Eastern Powder River Basin (FES 74-55), some observable results have been made available on reclamation success in the region and adjacent areas. The results enumerated below for two currently operating surface mines in the Eastern Powder River Basin were taken *from Rehabilitation Potentials and Limitations of Surface Mined* Land *in the Northern Great Plains* (Packer 1974).

Wyodak Resources Development Corporation (Wyodak Mine). This mine is on the Wyodak seam near Gillette. The top 10 feet of overburden is sandy and has no adverse chemical characteristics. Spoil banks have been graded to a level or gently sloping configuration. In the spring of 1972, the spoil banks were lightly disked and seeded to crested wheatgrass, green needlegrass, western wheatgrass, and fourwing saltbush. No supplemental irrigation was applied. Excellent stands were obtained by planting on spoils from both shallow and deep depths; however, vigor of stands grown on spoils derived from shallow depths was better. Short-term conclusions about this mine are that (1) the overburden from deep depths is

TABLE R4-6

VEGETATION TYPE DISTURBANCE IN THE REGION (IN ACRES AT THREE BENCHMARK DATES)

Probable Level of Regional Development	Sagebrush/ Grass	Scória Grassland	Silver Sagebrush	Greasewood	Ponderosa Pine	Riparian	Others Combined	Total Acres
1980 Total	20,704	634	625	192	87	454	178	22,874
1985 Total	36,520	1,061	1,018	321	146	786	279	40,131
1990 Total	45,983	1,406	1,336	425	194	1,030	229	50,603

Note: Table does not include acreage disturbed due to population increase since it is unknown what types will be disturbed. This would amount to 400 acres by 1980, 1,800 acres by 1985, and 2,200 acres by 1990.

not toxic, (2) spoil banks finished off with near-surface material provide better growth, (3) rehabilitation can be accomplished without irrigation, and (4) good rehabilitation success can be achieved.

Amax Coal Company (Belle Ayr Mine). This mine is on the Wyodak seam south of Gillette. The overburden, which consists of mixed sandstone, claystone, and shale, is quite sandy. No toxic or sterile overburden has been encountered. As at the Wyodak Mine, the upper 10 feet of overburden is best for final emplacement on graded spoils. Spoils have been shaped to gentle slopes similar to the natural topography. No serious erosion problems exist. Amax, the University of Wyoming, and the U.S. Forest Service have established successful rehabilitation plantings at this mine. Amax has planted most of the areas that have been rehabilitated. Approximately 400 acres, used for spoil disposal from the mine pit, have been planted to grasses, forbs, and shrubs and are used for cattle grazing. Another 25 acres, more or less, have been planted to protect and stabilize mine spoils. The University of Wyoming has successfully established a number of grass and legume species on an experimental area of only a few acres. Similarly, the U.S. Forest Service has an experimental planting of several shrub and tree species (225 of each species), some of which have established successfully.

Among the grass and shrub species that have been successfully grown on the Belle Ayr Mine are western wheatgrass, green needlegrass, tall wheatgrass, and fourwing saltbush. No mulches or irrigation have been used in connection with these plantings. Some areas have been fertilized, however.

Short-term conclusions based on results of rehabilitation efforts are that (1) grading of spoils to gentle slopes reduces or eliminates erosion of the soil surface, (2) fertilizer improves initial growth while the ground is still moist, but apparently does not enhance survival after the ground dries, (3) native and adapted introduced grasses and shrubs establish and survive well, especially where the top 10 feet of overburden has been used to finish off the spoil surface, and (4) in years of average and above-average precipitation, initial establishment of adaptable plant species should not be difficult.

Since the above report was published in 1974, follow-up field checks were made in 1978. The Soil Conservation Service in Gillette reports (personal communication) that productivity on seeded spoil banks at the Belle Ayr Mine varies from 90% to better than 100% of the productivity on comparable nonmined areas. This productivity rate applies to areas seeded since 1972. (However, 1978 was an exceptionally good moisture year, with grasses growing over 2 feet tall.) The same revegetation success was exhibited at the Cordero Mine (5 miles south of the Belle Ayr Mine) in 1978.

More data on reclamation results will become available as the results of current studies are published.

The removal of vegetation from stripping areas, access roads, the main rail line, rail spurs, and its destruction under piles of overburden, would lead to increased use of remaining vegetation by livestock and wildlife. The railroads and access roads could act as barriers to livestock and wildlife movement and cause trailing or increased use on the vegetated area adjoining these facilities. The magnitude of these secondary impacts would depend on the importance of the area for wildlife and livestock forage.

Increased dispersed recreational use, particularly that involving off-road vehicle travel, would cause the disturbance of an indeterminate amount of vegetative cover. Baseline data are not available on acres of vegetation disturbed by this activity. An indication can be drawn from the magnitude of the anticipated population increase (refer to Chapter 4, Recreation and Socioeconomic Conditions).

Another population-related impact to vegetation would be wildfires. In 1976, 3,500 acres of vegetation were destroyed in the region by 82 wildfires. (These are figures actually submitted to State of Wyoming (personal communication, Mike Gagin 1977); unreported fires probably occurred.) The usual causes are lightning or human activities. The incidence of lightning-caused fires (22 in 1976) is expected to remain relatively constant as little or no change is anticipated in the climatic condition or fire potential in the vegetative communities of the region. The number of man-caused fires (60 in 1976) is expected to increase with expansion of the population. However this increase can be offset with quicker detection and response as a result of more people. Also more fire equipment would be available at mine sites.

Haul road dust and coal dust resulting from mining operations may be deposited on vegetation adjacent to the mine areas. Dust releases from one existing mine were estimated to amount to 44 pounds of dust per hour per mine (University of Wyoming, Black Thunder Project Research Team 1976). Dust-covered vegetation would be less palatable to livestock and wildlife and could become unfit for consumption until cleaned by rain, snow, or wind.

Another impact from the destruction of vegetative cover could be the invasion of noxious weeds or less palatable species of vegetation onto the disturbed areas. These weedy species would compete with and inhibit the reestablishment of desired permanent vegetative cover. Young, palatable plants produced by revegetation efforts would attract livestock and wildlife. The grazing of the young plants, unless controlled, would inhibit growth vigor and could cause a delay in the establishment of vegetative cover.

Aquatic Vegetation

Mining would eliminate aquatic habitats in certain localized areas, for example Rawhide Creek on the Buckskin site (see Map 1, Appendix A, and Table R4-4). In nearby offsite areas, aquatic habitats in groundwater-fed ponds would probably be eliminated due to lowered water table levels.

Surface runoff from disturbed areas could increase the sediment load in streams. This increase would degrade the aquatic community and destroy individual plants by suffocation and abrasion.

Endangered and/or Threatened

As discussed in Chapter 2, no plant species listed as endangered or threatened are known to occur in the region. Hence, no adverse impact would be anticipated. However, all proposed mining and related areas would be intensively inventoried by qualified plant specialists to determine whether endangered or threatened plants exist.

FISH AND WILDLIFE

The effects of cumulative regional development on wildlife can be categorized by: (1) the loss of fish and wildlife habitat, (2) the resulting loss of fish and wildlife carrying capacity due to the loss of habitat, and (3) the loss of fish and wildlife populations and their progeny. The impacts to fish and wildlife habitat and populations are summarized in Table R4-7. Additional data from the Wyoming Game and Fish Department will be utilized to improve this analysis, as that data becomes available.

Habitat Loss

The amount of disturbance that would result in each of the habitat types is described in Chapter 4, Vegetation. An estimated 92.2% of all surface disturbance would take place in the sagebrush-grass habitat type.

Animals inhabiting areas which are disturbed for mining or construction would be directly affected in one of two ways: they would either be killed immediately (e.g., reptiles, burrow-dwellers) or displaced to surrounding areas (e.g., large mammals, birds). Most of those displaced would not be able to compete successfully for food and territory, and would be lost.

Displacement and subsequent loss of wildlife would also occur in areas adjacent to development areas. The main causes of displacement and loss would be human activity and noise, which affect each wildlife species in various ways and to varying degrees. Even individuals of the same species can react differently to these two forms of disturbance. In general, the more sensitive and secretive a species, the farther it will be displaced by human activity. The area of displacement for each species is unknown, but this area may be as large or several times larger than the mine site or other development itself.

An unknown amount of fish and wildlife habitat would be destroyed by the increased human population that would accompany regional development. Habitat destruction would occur mainly from increased off-road vehicle use and increased frequency of man-caused fires. Increased human intrusion into normally undisturbed areas may stress some wildlife causing displacement and subsequent loss.

Reclamation would be an ongoing process following mining and other surface disturbance. Reclamation would compensate for some of the wildlife habitat destroyed. However, since grasses have been the primary species used for reclamation, wildlife diversity and use of these areas would be reduced due to the absence of vegetative diversity. The reclaimed areas would also be void of any protective cover, which would further discourage the use of reclaimed areas by many wildlife species. The primary species groups that would benefit from reclamation would be nongame birds and small nongame mammals.

Carrying Capacity Loss

As habitat is destroyed, the area looses its carrying capacity, or ability to support fish and wildlife populations. All mineral development and related activity presently occurring or due to occur within the analysis period would cause a loss of carrying capacity in the region on 23,274 acres in 1980, 41,931 acres in 1985, and 52,803 acres by 1990. As stated above, reclamation would restore some habitat and thus some carrying capacity, but the number of species that would benefit would be few.

Fish and Wildlife Population Losses

Fish

Stream degradation would occur in some drainages within the region due to siltation and pollution from sewage and other contaminants from new or existing mines, mills, power and gasification plants, oil and gas wells, population centers, and all other development described in Chapter 1.

Nongame. Nongame population in two stream fisheries would be affected by expansion of existing coal mines. An estimated 2-mile section of Little Thunder Creek and a 7½-mile section of Caballo Creek would be destroyed and rechanneled through the mined areas during reclamation. Nongame species inhabiting these streams include carp, white sucker, fathead minnow, and sand shiner.

Game. Populations of green sunfish and black bullhead inhabiting Caballo and Little Thunder creeks would be affected by mining.

Two reservoirs containing game fish would also be destroyed by expansion of existing coal mines. Caballo Reservoir, a 21-acre impoundment planted with rainbow trout, and Reno Reservoir 01, a 50-acre impoundment containing largemouth bass, would be destroyed. Both reservoirs would be replaced at new locations during reclamation of the mined areas.

Endangered and/or Threatened Species. No known endangered or threatened fish species would be affected by development, since none is known to occur in the region.

Wildlife

An unknown quantity of wildlife would be lost due to the increased human population. There would be increased vehicle-animal collisions, poaching, wanton destruction, and predation by household pets.

TABLE R4-7

SUMMARY OF ADVERSE IMPACTS OF REGIONAL DEVELOPMENT ON WILDLIFE

		Fishery		Estimated Individuals Lost						
				Birds			Mammals			Reptiles and Amphibians
								Game		
	Habitat Loss			Nongame	Game*	Raptors	Nongame	Antelope	Deer	
1980	23,274 Acres			118,697	4,746	131	88,441	748	107	NA
1985	41,931 Acres	2 Streams 9½ Miles	2 Reservoirs 71 Total Acres	213,848	8,550	236	159,338	1,351	194	NA
1990	52,803 Acres			269,295	10,767	297	200,651	1,702	245	NA

Note: The numbers of individuals affected by habitat loss, as shown in the table, were developed by multiplying the acres disturbed by the density of each species or groups of species. The number of individuals affected is directly proportional to the acreage disturbed; therefore the total habitat disturbed for 1980, 1985, and 1990, represents 0.5%, 0.8%, and 1.0% respectively of the total 4,978,560 acres of habitat in the region. These percentages also represent the relationship between the numbers of wildlife affected and the total regional wildlife population.

* Only doves. Density figures, and hence loss figures, may be modified after results of the current Wyoming Game and Fish Department study become available.

NA = not available.

Birds. Birds would be subject to the aforementioned human-related impacts and to an unknown degree by collision with aerial obstacles such as power lines, by electrocution on power lines, and by impurities in settling and waste ponds.

Nongame. The main nongame bird species that would be affected by development are the sage sparrow, horned lark, sage thrasher, lark bunting, vesper sparrow, and meadowlark.

Table R2-8 in Chapter 2, Wildlife shows the results of density studies conducted by some of the mine companies on their leases. The average density of 5.1 birds per acre from the table was used to project losses from other development in the region. Direct loss of nongame birds that would be caused by development in the region would total approximately 118,697 by 1980, 213,848 by 1985, and 269,295 by 1990. Nongame bird losses in 1990 would represent approximately 1% of the total regional nongame bird population.

Raptors. Studies conducted by mine companies indicate that the average density for raptors in the region is an estimated 3.6 birds per square mile. The total number of raptors that would be directly affected in the region is estimated at 131 by 1980, 236 by 1985, and 297 by 1990.

Game. The regional density of doves is estimated at 130.5 per square mile (see Table R2-8). Direct losses of doves would be an estimated 4,746 by 1980, 8,550 by 1985, and 10,767 by 1990. The regional loss of waterfowl due to all development is unknown. Sage grouse would also be affected by regional development, but the number is unknown. Density studies for the latter species are currently underway.

Endangered and/or Threatened Species. There are three endangered species of birds which may occur in the region: the peregrine falcon, the whooping crane, and the bald eagle. It is possible that peregrine falcons migrate through the region; however, they probably would not be affected by development within the region. The whooping crane is a possible migrant, and would probably not be affected by regional development.

The bald eagle is normally only a winter resident of the Eastern Powder River Basin. The bald eagle usually nests near major drainages or large impoundments. The major drainages in the region have either small or intermittent flows and it is unlikely that these areas would be considered as preferred nesting habitat. Some of the eagles' winter hunting habitat may be lost due to development in the region; however, no federal action, including the site-specific proposal, is anticipated to have any adverse impacts on bald eagles or their wintering habitat.

Mammals.

Nongame. The major nongame mammal species that would be affected are the deer mouse, thirteen-lined ground squirrel, northern grasshopper mouse, meadow vole, and the least chipmunk.

Total direct losses of small game mammals (including cottontail rabbits, a small game mammal) in the region would be approximately 88,441 by 1980, 159,338 by 1985, and 200,651 by 1990. Nongame mammal losses in 1990 would represent approximately 1% of the regional nongame mammal population.

Game. Using an average density figure of 3 per square mile for mule deer, direct losses of 107 by 1980, 194 by 1985, and 245 (.8% of estimated regional total) by 1990 could be expected. Antelope losses (estimated density of 20.8 per square mile) would amount to 748 by 1980, 1,351 by 1985, and 1,702 (3.5% of estimated regional total) by 1990.

Endangered and/or Threatened Species. The black-footed ferret is the only mammal listed as endangered which may occur in the region. The preferred habitat of the black-footed ferret is prairie dog towns. The black-footed ferret or its habitat is unlikely to be affected by development in the region because prairie dog towns are not found on or near the sites being developed.

Reptiles and Amphibians.

General. The main amphibian and reptile species affected by development would be the leopard frog, tiger salamander, boreal chorus frog, prairie rattlesnake, bull snake, horned lizard, and the sagebrush lizard. Densities are unknown, so it is impossible to predict losses.

Endangered and/or Threatened Species. Development would not affect any threatened or endangered species, since none is known to occur in the region.

CULTURAL RESOURCES

Possible adverse effects of any development as listed by the Advisory Council on Historic Preservation consist of (1) destruction or alteration of all or part of a property, (2) isolation from or alteration of its surrounding environment, or (3) introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting (36 CFR 800.9). Possible effects are not limited to these criteria, and each project must be evaluated to determine effects to specific cultural resources. Cultural resource inventories and compliance required by the Historic Preservation Act of 1966 and Executive Order 11593 must be conducted before approval of any federal action; however, projects without federal involvement may not always be inventoried.

Salvage of cultural resources allows recovery of significant amounts of scientific data. However, current research methods and priorities may overlook sites or portions of sites which would have been important to future research. Also, some sites not selected for salvage may be destroyed with recovery of only preliminary inventory data. These decisions may result in loss of valuable cultural resources.

Cultural resource inventories of planned or projected developments represent over 98% of the acreage inventoried in the region and account for over 95% of the known sites.

Coal development in the region has accounted for the largest percentage (94%) of cultural resource inventories. On a regional basis, 100% of the land approved for coal development has been inventoried. To date, no known significant loss of cultural resource data has occurred because salvage has been possible on all significant sites.

No sites which deserve long-term protection for future research have been identified on coal tracts. Coal development has provided funding for cultural resource studies in an area which previously had not received much professional interest.

Cultural resource sites in uninventoried areas may suffer the greatest adverse effect since salvage cannot be conducted on unknown sites. The extent of loss to cultural resources would depend upon location of individual sites and developments. The significance or numbers of undetected and uninventoried sites within the region cannot be determined without extensive inventories.

Increased populations would cause increased unauthorized collection and vandalism of both known sites and uninventoried sites. Presently, very few sites have been identified which have not been damaged to some extent, and any increase in vandalism may impair the future research of significant values.

National Register

The Bozeman Trail and related sites are the only National Register quality sites in the region which may be affected by regional development. Development of coal, uranium, oil and gas, and utility lines would cause increased activity and use along the Bozeman Trail. Such development would create temporary visual elements which are out of character with the open historic setting of the trail. Some physical evidence of the trail system may be damaged by off-road vehicle use because of increased population and use of the area.

VISUAL RESOURCES

The cumulative effect of regional development on visual resources would be a continuation of the gradual changes now occurring in the Eastern Powder River Basin. Municipal growth and mineral development in rural areas would result in actual loss of open space and would transform the region from a quiet, relatively uninhabited area to one busy with human and industrial activity.

The two predominant visual resource management classes of the region (III and IV) would be changed on a site-specific basis for the life of each mine, coal conversion plant, or uranium mill to Class V (interim classification for intrusion) by the alteration of landforms, and by the installation of mine structures and support facilities such as rail spurs and power lines. Reclamation would reduce the contrasts, and over the long term, restore the land to its original visual resource management class. Urban expansion and scattered housing and commercial development would permanently alter the visual character where they occur.

Scenic views would be changed. Indicators of this change would be roadside billboards, scattered housing tracts outside cities, and unregulated trash disposal and litter near plants and communities. Views of distant mountains may be obscured by haze resulting from increased vehicular and industrial emissions, and from fugitive dust. New vertical intrusions, such as coal storage silos and power plant stacks, would interfere with the natural landscape.

The greatest visual impacts would be experienced where the region's federal, state, and local roads provide visual access to the mineral development and urban areas.

RECREATION RESOURCES

The primary effect of total regional development would be increased numbers of people participating in and demanding recreation opportunities. The projected regional population increase by 1990 due to all development is 86% (see Table R1-3). Developed recreation areas and public lands in and surrounding the region would absorb additional use. Overcrowding would result, leading to vandalism and increased maintenance and repair costs. (Managing agencies such as the U.S. Forest Service and the Wyoming Recreation Commission do not plan development of new facilities, only expansion and maintenance of existing ones.) For those accustomed to solitude and wide open spaces, overcrowding would also reduce the quality of their recreation experience. Municipal facilities in particular would be inadequate to meet local needs; although the tax base would increase as a result of mineral development, there would be a lag between need and the availability of money for expansion of facilities. Finally, because of the small proportion of public land in the region available for recreation, overcrowding may increase the number of landowner conflicts with recreationists.

Cumulative regional mineral and municipal development would disturb approximately 52,803 acres by 1990. Most of this land is privately owned, but disturbance would remove some land currently available for recreation uses—mostly hunting or off-road vehicle use. Such removal would further concentrate recreation use on remaining land.

Recreation Participation Data

Table R4-8 shows the projected trends in recreation participation for the region through the year 1990.

Hunting

Hunting would continue to be the major dispersed recreation activity in the Eastern Powder River Basin. Although wildlife populations statewide are projected to increase through 1990 (Wyoming Game and Fish Department 1975), loss of approximately 52,803 acres in the region due to all development would reduce game populations by 1,702 antelope and 245 deer by 1990. At the same time, hunting demand is expected to increase 151% by 1990. This would result in lower hunter success ratios, an increase in the amount of time required to get

TABLE R4-8

ESTIMATED RECREATION TRENDS, CAMPBELL AND CONVERSE COUNTIES
VISITOR DAYS

		1980	1985	1990	% Increase 1990 over 1975
Attending Athletic Events					
	Converse	21,000	24,000	27,000	
	Campbell	49,000	68,000	86,000	
		70,000	92,000	113,000	133%
Boating and Canoeing					
	Converse	11,000	15,000	18,000	
	Campbell	58,000	76,000	94,000	
		69,000	91,000	112,000	135%
Camping					
	Converse	66,000	78,000	90,000	
	Campbell	64,000	210,000	256,000	
		230,000	288,000	346,000	101%
Fishing					
	Converse	39,000	46,000	53,000	
	Campbell	54,000	80,000	106,000	
		93,000	126,000	159,000	166%
Golfing					
	Converse	20,000	23,000	26,000	
	Campbell	70,000	97,000	124,000	
		90,000	120,000	150,000	152%
Hiking					
	Converse	33,000	37,000	41,000	
	Campbell	60,000	78,000	96,000	
		93,000	115,000	137,000	92%
Hunting					
	Converse	21,000	25,000	29,000	
	Campbell	48,000	67,000	86,000	
		69,000	92,000	115,000	151%
Ice Skating					
	Converse	7,000	9,000	11,000	
	Campbell	17,000	21,000	26,000	
		24,000	30,000	37,000	106%
Picnicking					
	Converse	17,000	20,000	22,000	
	Campbell	73,000	88,000	103,000	
		90,000	108,000	125,000	74%

TABLE R4-8
(cont'd)
ESTIMATED RECREATION TRENDS, CAMPBELL AND CONVERSE COUNTIES
VISITOR DAYS

		1980	1985	1990	% Increase 1990 over 1975
Rodeos					
	Converse	30,000	34,000	39,000	
	Campbell	24,000	30,000	36,000	
		54,000	64,000	75,000	73%
Sight-Seeing and Pleasure Drives					
	Converse	68,000	81,000	95,000	
	Campbell	166,000	230,000	293,000	
		234,000	311,000	388,000	147%
Snow Skiing					
	Converse	5,000	7,000	9,000	
	Campbell	14,000	20,000	27,000	
		19,000	27,000	36,000	277%
Sledding and Tobogganing					
	Converse	3,000	4,000	4,000	
	Campbell	7,000	9,000	11,000	
		10,000	13,000	15,000	106%
Snowmobiling					
	Converse	5,000	6,000	6,000	
	Campbell	21,000	27,000	32,000	
		26,000	33,000	38,000	85%
Softball and Baseball					
	Converse	17,000	22,000	26,000	
	Campbell	42,000	53,000	65,000	
		59,000	75,000	91,000	106%
Swimming					
	Converse	32,000	35,000	38,000	
	Campbell	93,000	112,000	132,000	
		125,000	147,000	170,000	67%
Water Skiing					
	Converse	5,000	5,000	6,000	
	Campbell	16,000	21,000	26,000	
		21,000	26,000	32,000	118%
Tennis					
	Converse	4,000	5,000	6,000	
	Campbell	10,000	13,000	15,000	
		14,000	18,000	21,000	107%
Total		1,276,000	1,633,000	1,991,000	117%

Source: Derived from Wyoming Recreation Commission 1975

an animal, and possibly hunting restrictions such as smaller hunt areas and shorter seasons.

When human population and hunting pressure increase, some ranchers may make their property available to hunters as a business opportunity by charging "trespass"-fees. However, other private land may be closed and posted, further reducing the recreation land base. The loss of private land for hunting could be more significant than the physical loss of land to mineral development.

Hunting quality in the region is not expected to return to its present level because of the long-term impact of regional development on wildlife populations and habitat (see Chapter 4, Wildlife). Furthermore, big game hunting (for the Wyoming resident) has traditionally been as much for the meat as the sport. Trespass fees or consistent lack of success would make hunting uneconomical. The decline in hunting quality and opportunity would cause resident and nonresident hunters to seek their recreation in other parts of the state.

Fishing

Two small reservoirs stocked with game fish would be directly affected by the regional development. The quality of the water and hence the fisheries throughout the region may be reduced by increased sediment levels or sewage (see Chapter 4, Water Resources and Wildlife). By 1990, the demand for fishing is expected to increase by 161%. The Wyoming Game and Fish Department (personal communication, Mike Stone 1977) estimates that fisheries such as Keyhole Reservoir could, if properly managed, absorb substantially more fishing pressure; however, as more people participate, the quality of the experience would diminish. This would be particularly true of the North Platte River impoundments and streams in the Laramie Mountains which are used by residents of the Cheyenne area and northern Colorado, as well as by residents of the region.

Winter Activities

Participation in skiing (downhill and cross-country) and snowmobiling would increase with population. Lack of sufficient snow base, suitable terrain, and access to public and private land would continue to cause residents of the region to seek winter recreation in the nearby mountain ranges. The U.S. Forest Service could expect the majority of this increased use to occur on national forest lands, resulting in management problems. Potential problems or magnification of existing problems include conflict between various groups (e.g., snowmobilers vs. cross-country skiers), litter, noise pollution, wildlife harrassment, and damage to the soils and vegetation. Because of limited amounts of public land in the region, more people with snowmobiles would be tempted to trespass on private lands causing landowner-recreationist conflicts.

Water-based Recreation

Boating, swimming, and water skiing would experience increased participation and demand (see Table R4-8). Overcrowding may occur, resulting in a reduction of the quality of recreation; management agencies such as the Wyoming Recreation Commission may find it necessary to place restrictions on the number of boats in order to provide for public safety.

Historical Interest/Sight-Seeing

Sight-seeing for scenery and historical interest would increase due to the increased number of people in the region. Energy development would have both positive and negative impacts on sight-seeing. Coal development and associated facilities would provide interesting and educational viewing for travelers on nearby roads and visitors to the mines themselves. Depending on the viewer's perspective, the mines and related development could provide man-made variety to an otherwise monotonous landscape.

From a negative standpoint, the mines and related development would be intrusions in a traditionally agricultural setting. Increased traffic and concentrated human activity would tend to displace wildlife away from roads used by sightseers.

Camping/Picnicking

Camping and picnicking would increase along with other activities. The brunt of the impact could be expected to occur at developed sites such as Keyhole Reservoir, Devils Tower National Monument, the North Platte reservoirs, and national forest lands. The resident would be competing with the nonresident for these resources. The various management agencies could find maintenance costs increased and the necessity to restrict and limit length and type of use. Conflicts between users would increase, and the quality of the experience for the recreationist who prefers solitude would be reduced.

Off-Road Vehicle (ORV) Use

The current proportion of people owning four-wheel drive vehicles and dirt bikes (35% and 12.5% respectively in Gillette) (University of Wyoming 1976) could be expected to continue as the population of the region grows. Areas of mining and municipal development would be removed from the available recreation land base. This means that landowner-recreationist conflicts, damage to vegetation and soil on existing public land, and annoying noise levels near residential areas may be greatly aggravated.

National forest lands and those administered by the Bureau of Land Management would bear the brunt of in-

creased ORV use. The Bighorn National Forest has experienced a recent increase in ORV use and the number of law violations (personal communication 1978). Prevention of ORV damage would require increased supervision, education, and possible restrictions by all land management agencies.

Wilderness Values

The region's one nearby existing primitive area (Cloud Peak), and the five that have been identified as wilderness study areas or roadless areas, would be impacted by increased use. The number of visitor days devoted to hiking is projected to increase 72% by 1990 (Table R4-8). To prevent overuse and preserve wilderness character, the number of people using these areas may have to be limited.

AGRICULTURE

Taken together, all of the proposed energy developments including existing and proposed coal mines, uranium mining, oil and gas development, sand and gravel use, and resulting population increases would create large problems and dislocations for agriculture in the Eastern Powder River Basin of Wyoming.

All development on a cumulative basis would result in land use changes on approximately 52,803 acres by 1990. Of this amount, 29% (15,594 acres) would have been permanently removed from production by construction of plant facilities, residential areas, roads, and railroads. The remaining 37,209 acres would be in some stage of temporary disturbance or reclamation. Although lands would be reclaimed and eventually restored to agricultural use, the cumulative impacts of regional development would have detrimental and far-reaching effects on agricultural land use. The degree of impact on each ranch operation would vary greatly due to the location of the individual holdings (owned and leased) in relation to the proposed development.

(In the following sections on impacts most figures used are derived from Tables R1-2 through R1-6.)

Livestock Grazing

Direct loss of livestock forage would occur on 12,291 acres by 1980 through construction of plant facilities, residential and commercial areas, roads, and railroads. Acres of forage lost at the end of other benchmark periods would be 15,094 by 1985 and 15,594 by 1990. Grazing loss on this acreage would be approximately 2,686 animal unit months (AUMs) by 1980, 3,018 AUMs by 1985, and 3,118 AUMs by 1990. This loss would last as long as the facilities, roads, or buildings exist and would be considered a long-term loss. (See Table R4-9.)

Reclamation of the mined land would be accomplished at approximately the same rate as acreage is disturbed; however, reclaimed areas are not expected to reach full production until 7½ years after seeding. The total acreage that would be reseeded but unable to support grazing would amount to 4,290 acres by 1980, 13,190 acres by 1985, and 20,000 acres by 1990. Temporary annual grazing loss on this acreage would be 858 AUMs in 1980, 2,638 AUMs in 1985, and 4,000 AUMs in 1990.

Impacts associated with population increases would occur. Recreation use could cause a nuisance problem (gates left open, livestock molestation, etc.) and might cause temporary impairment of livestock forage use. The proliferation of roads, access along with increased population, could result in increased vandalism of fences and other range facilities by outdoor recreationists. Rustling of individual animals and the molestation of grazing animals by off-road vehicle users could develop into serious problems, especially during calving and lambing.

The development of coal and uranium mines, oil and gas wells, power plants, a gasification plant, and the construction of facilities such as access roads, transmission lines, fences, a railroad, and rail spurs would lead to land separation, destruction of range allotment fences, pasture severance, crossing delays, and possibly alteration of present land ownership patterns. These developments would disrupt grazing use patterns, cause access problems to livestock watering areas and pastures, and increase the costs of caring for the livestock. Livestock losses would be expected to occur from obstacles created by additional fences and/or from collisions with vehicles.

Mine development could cause some obliteration of existing watering facilities for the duration of mining activities in the area. Mining of aquifers could dry up livestock water (wells or springs) in surrounding areas. (See Chapter 4, Water Resources.) This could result in nonuse of grazing areas if their locations are remote from remaining water sources.

Some grazing lands could be affected by increased erosion and sedimentation. Alteration of drainages by mining could cause accelerated erosion and headcutting in productive bottomlands, resulting in additional losses of livestock forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

Products of industrial activity, such as dust and noise, would discourage grazing in the proximity of such activity and render much land unavailable for grazing.

Dust and potentially toxic chemicals could adversely affect vegetation on and near the sites. As a result, both the productivity and palatability of vegetation could be reduced. This would, in turn, reduce the carrying capacity of undisturbed range and reclaimed land for domestic stock and wildlife. Although the acreages potentially affected are not precisely known, the most serious effects would probably be confined to a relatively restricted area downwind from and adjacent to the mine pit, haul and access roads, the rail spur, the coal loading facilities, or the plant site.

In addition to reduced carrying capacity, other direct effects of air pollutants on domestic and wildlife grazers would be possible. Chronic exposure to sulfur and nitrogen oxides can injure animals (University of Wyoming,

TABLE R4-9

SUMMARY OF PROJECTED LOSS OF AGRICULTURAL LAND AND PRODUCTION

Probable Level of Development	Total Land Area Permanently Removed From Livestock Forage Production (During Mine Life)	Annual Livestock Forage Lost Permanently (During Mine Life)	Land Removed From Crop Production (Based On Total Acres Disturbed)		Annual Hay Production Lost (Tons)			Annual Dryland Wheat Lost (Bushels)	Other Cropland Lost (Acres)	
	(Acres)	(AUMs)	(Acres) Dryland	(Acres) Irrigated	Dryland .78 Tons/Acre	Irrigated 1.62 Tons/Acre	Total Tons	18.6 Bushels/Acre	Dryland	Irrigated
1980 Total	12,291	2,686	568	158	288	192	480	3,636	91	39
1985 Total	15,094	3,018	926	264	436	322	758	6,035	131	65
1990 Total	15,594	3,118	1,213	349	554	425	979	7,957	163	86

Black Thunder Project Research Team 1976). Also, fugitive dust from overburden and coal may contain varying amounts of heavy metals. If concentrations of these heavy metals are high enough, chronic poisoning of animals via ingestion of contaminated vegetation and water would be possible. Such chronic poisoning from deposited heavy metals from industrial releases is well documented for cattle, horses, sheep, goats, and wildlife (ibid.). However, since neither the ground-level concentrations of gaseous pollutants nor deposition rates of particulate pollutants are known, the extent of any adverse effects on domestic and wildlife grazers cannot be predicted.

Physical separation of private land from adjoining federal grazing lease land, and division of grazing allotments by fenced rights-of-way may necessitate realignment of grazing allotment boundaries and users. Some loss of grazing use on federal lands would occur due to coal development activities and is included within the total projected loss of agricultural land and production.

Ranchers would have difficulty competing for the labor market as industrial wages increase.

Farming

Loss of nonirrigated farmland production is based on actual data submitted by the mining companies. A summary of the projected loss of crop production and farmland is contained in Table R4-9.

Possible impacts to irrigated croplands are anticipated to occur due to direct destruction of irrigated lands and the projected expansion of Douglas. Additional irrigated cropland may be affected by industrial water diversions and rights-of-way for roads, pipelines, railroads, and similar developments.

Loss of productive irrigated cropland would also occur from conversion of irrigation water rights to industrial use. Additional purchases of irrigation water rights are presently being made throughout the Eastern Powder River Basin and the North Platte River system in Wyoming for use in coal development inside and outside of the region. Irrigation water is the major supply available to industry, although some plans are being developed to obtain water from deep wells.

Based on present information, water is already in short supply to many areas of irrigated croplands. Loss of water for irrigation could not be readily replaced from existing sources. Approximately 6% of the available irrigation water would be needed to satisfy the projected industrial and municipal needs by 1990. This represents the loss of a source of winter feed to the livestock industry equal to 67,200 tons of hay in an area with a winter feed deficit.

Irrigation systems themselves could be completely destroyed by mining activity.

Prime and Unique Farmland

It is possible that prime farmlands may be impacted by energy development. No formal designation of prime farmland in the region has occurred as yet. Agricultural lands on proposed surface mine sites will be analyzed on a site-specific basis to determine whether they meet the criteria for prime farmland as defined by the Surface Mining Control and Reclamation Act (see Chapter 2, Agriculture).

FOREST RESOURCES

No impact to marketable forest resources is expected from regional development activity.

MINERAL RESOURCES

Coal

The impact to coal resources of the region is the consumption of the resource As of January 1, 1975, a cumulative total of 44.38 million tons of coal (Glass 1976) had been produced from the region. This is .06% of the minable and .2% of the strippable total original estimated coal resources of the region (see Table R2-14). Production figures for 1975-1977 are not available, but in 1978, production from the region is expected to be 49.5 million tons (see Table R1-1, Chapter 1) or .07% of the minable and .2% of the strippable coal resources of the region. In 1979-1980, cumulative production is expected to increase to 182 million tons or .2% of the minable and .8% of the strippable coal resources; in 1981-1985, to 749 million tons or 1% of the minable and 3.6% of the strippable coal resources; and in 1986-1990, to 886 million tons or 1% of the minable and 4% of the strippable coal resources of the region.

By 1990 a cumulative total of approximately 2 billion tons or more than 2.6% of the minable and 9.2% of the strippable coal resources of the region would have been consumed.

Other Mineral Resources

Coal development would not significantly impact the production of other mineral resources of the region.

Oil and gas is being produced from 166 fields in the region. Production has shown a decline since 1973, a trend that is expected to continue as the reserves are depleted.

Current and projected uranium mining would consume the uranium resources of the region. The Nuclear Regulatory Commission (1977) currently estimates the reserves in the Powder River Basin to be 25,400,000 tons of uranium ore. As discussed in Chapter 1, by 1990 it is anticipated that six mines will be providing a total of 9,500 tons per day of uranium ore, or 3,467,500 tons annually.

Sand, gravel, and scoria would continue to be quarried to meet demands for road and construction materials, and that resource would be gradually consumed.

TRANSPORTATION NETWORKS

Railroads

This section discusses the projected impacts of coal mining activities on rail traffic flowing through and out of the Eastern Powder River Basin.

Projected increases in coal and noncoal freight train traffic traversing the Eastern Powder River Basin are shown in Tables R4-10 and R4-11. Figure R4-11 displays coal train traffic over various segments of the Burlington Northern (BN) system.

At present, coal shipments from the Eastern Powder River Basin must be transported via the BN route through Donkey Creek and on to Alliance, Nebraska (see Figure R4-11). This track's current two-way maximum capacity of 40 to 65 trains per day must be upgraded by 1980 to accommodate the coal train traffic projected in Table R4-10.

However, by mid-1980, the rail strip currently under construction between Donkey Creek and Orin Junction, Wyoming, will be available to relieve the pressure on the present BN line. This link between the BN rail line and the Eastern Powder River Basin coal mining region will make an alternative traffic route for coal shipments available. Coal trains will be able to move south on the BN line toward Torrington, as well as north toward Donkey Creek. BN anticipates approximately half of the coal trains originating in the Eastern Powder River Basin would move north and about half south (personal communication, Jerrold G. Wood, Director of Public Works, Burlington Northern, Inc. 1978).

Anticipated impacts on communities located along the two routes are discussed in greater detail below. However, in general, most of the problems of pedestrian and vehicle access, isolation of parts of towns, and safety hazards (see Chapter 2) would be intensified. Trains would pass through these communities at a rate of over two an hour, causing railroad crossings between Donkey Creek and Alliance to be occupied between 3 and 6 hours per day, assuming train speeds vary between 10 and 50 miles per hour.

Northern Route

Sheridan and Gillette, two communities reviewed in Chapter 2, would not experience increased train traffic from the Eastern Powder River Basin coal mines, because most of the coal trains would connect with the BN route east of Gillette at Donkey Creek. Nevertheless, the previous vehicle and pedestrian transit problems described in Chapter 2 would continue unless grade separations within the town or rail bypasses around the towns are constructed.

In 1978, rail crossings in Newcastle are blocked from 1-1/4 to 2-1/4 hours daily by passing trains. Based on the train traffic projections in Table R4-11 and train passage times of 3 to 5 minutes per train, the grade railroad crossings would be blocked an average of 3-3/4 to 6-1/4 hours daily in 1980 and 3-1/4 to 5-1/4 hours daily in 1985 and 1990.

It is unlikely that Alliance would get much relief from coal-related rail impacts once the Donkey Creek to Orin Junction rail strip is opened. Due to train and pedestrian traffic around a rail car inspection yard and a diesel locomotive repair facility, a train speed limit of 10 to 15 miles per hour is enforced. Each coal train, therefore, would take at least 4 to 6 minutes to travel past each grade crossing. This means that grade railroad crossings would be blocked an average of 4-1/2 to 6-3/4 hours daily between 1980 and 1990. If the two grade separations currently under review are constructed, vehicle transit problems should be resolved. However, the west side of town, an area separated from the rest of town by the railroad tracks, would become even more isolated from downtown Alliance.

Grand Island would also continue to experience heavy impacts from the coal trains. This is due not so much to coal trains from the Powder River Basin as it is from the combination of freight traffic from the Powder River Basin and the Hanna Basin (south central Wyoming). Railroad tracks of two carriers of coal (BN and Union Pacific) intersect in this community. Unless a solution to alleviate traffic congestion at this intersection is agreed upon, serious problems should be anticipated. Emergency vehicles and school buses, already experiencing significant delays, would be blocked at crossings for even longer periods of time. Access to the Hall County Airport in the northeast section of town would become more of a problem.

Southern Route

The opening of the rail line from Donkey Creek to Orin Junction and the movement of coal south on the BN line would expose communities not previously affected by coal trains to heavy train traffic.

By 1985 or 1990, some of the coal trains may be routed over the Chicago and North Western line (Figure R4-11) from Orin Junction through Lusk. The extent the route would be used, if at all, is still very indefinite. Considerable upgrading of this track would be necessary before any coal traffic could travel over this railroad. Due to the uncertainty surrounding this route, it was not included in our projections of rail traffic. However, if coal traffic were eventually routed over this rail line, a grade separation would be needed in the community of Lusk. (Personal communication, John Lane, Wyoming Highway Department 1978).

The community of Torrington was contacted about anticipated impacts. Due in part to the advance planning that has been possible, highway-railroad crossings are being upgraded and additional protective devices are being installed where needed. The improvements will

TABLE R4-10

ANNUAL UNIT COAL TRAIN VOLUME

	1980 Number of Unit Trains*	1985 Number of Unit Trains	1990 Number of Unit Trains	Market Destination**
Buckskin Mine	200	400	400	Oklahoma
Existing Mines				
Operating Mines				
Wyodak	45***	45***	45***	South Dakota, mine mouth (Wyodak Power Plant)
Dave Johnston	0***	0***	0***	Mine mouth (Dave Johnston Power Plant)
Belle Ayr	1,600	1,900	1,900	Colorado, Texas, Indiana, Missouri, Kansas, Oregon, Arkansas
Cordero	2,000	2,400	2,400	Texas, Wyoming
Rawhide	900	1,200	1,200	Nebraska, Indiana
Black Thunder	1,370	2,000	2,000	Nebraska, Oklahoma, Texas
Jacobs Ranch	1,070	1,570	1,540	Arkansas, Louisiana, Oklahoma
Eagle Butte	1,320	2,000	2,000	Southern, Midwestern, and Ohio Valley states
Kerr-McGee #16	420	420	420	Unknown

TABLE R4-10
(cont'd)

ANNUAL UNIT COAL TRAIN VOLUME

	1980 Number of Unit Trains*	1985 Number of Unit Trains	1990 Number of Unit Trains	Market Destination**
Environmental Statement in Progress				
Caballo	300	700	1,200	Unknown
Coal Creek	400	1,000	1,000	Unknown
East Gillette	400	1,100	1,100	Arkansas, Louisiana
Rochelle	0	0***	0***	Wyoming
Pronghorn	350	500	500	Unknown
Total	10,375	15,235	15,705	

1980 daily average = 10,375 trains per year ÷ 365 = 28.4 trains per day eastbound (loaded)
28.4 trains per day westbound (empty)
1985 daily average = 15,235 trains per year ÷ 365 = 41.0 trains per day eastbound (loaded)
41.8 trains per day westbound (empty)
1990 daily average = 15,705 trains per year ÷ 365 = 43.0 trains per day eastbound (loaded)
43.0 trains per day westbound (empty)

Source: Table R1-2.

* A unit coal train usually consists of 100 coal cars and 5 diesel units. Each car carries 100 tons of coal.
** Based on Western Oil Reporter February 1978.
*** This number does not represent full transport of the mine production by unit trains. Coal consumed at mine mouth is generally transported short distances by truck or private rail.

TABLE R4-11

DAILY TRAIN VOLUME PROJECTIONS FOR THE REGION

Train Type	1980* Number of Trains**	1980* Percent of Total	1985 Number of Trains**	1985 Percent of Total	1990 Number of Trains**	1990 Percent of Total
Northern Route						
Total Coal Trains:	67.9	91.9	56.9	90.5	58.2	90.6
Buckskin Mine***	1.1	1.5	2.2	3.5	2.2	3.4
Eastern Powder River Basin Coal Trains***	55.8	75.5	43.7	69.5	45.0	70.1
"Other" Coal Trains****	11.0	14.9	11.0	17.5	11.0	17.1
Non-coal Freight Trains*****	6.0	8.1	6.0	9.5	6.0	9.5
Total Coal and Non-coal Freight Trains	73.9	100.0	62.9	100.0	64.2	100.0
Southern Route						
Total Coal Trains:	0	0	43.7	84.5	45.0	84.9
Buckskin Mine***	0	0	0	0	0	0
Eastern Powder River Basin Coal Trains***	0	0	43.7	84.5	45.0	84.9
"Other" Coal Trains	0	0	0	0	0	0
Non-Coal Freight Trains	8	100.0	8.0	15.5	8.0	15.1
Total Coal and Non-Coal Freight Trains	8	100.0	51.7	100.0	53.0	100.0

* Train traffic expected on the Burlington Northern route in early 1980 before the Donkey Creek to Orin Junction rail strip is completed. If the rail strip were completed in 1980, about half of the coal trains originating in the Eastern Powder River Basin (i.e., 28.4 trains) would move south toward Orin Junction.

** Includes both loaded and empty train traffic.

*** See Table R1-2.

**** Burlington Northern estimate of coal trains in Gillette in 1982, personal communication, Jerrold G. Wood, Director of Public Works 1978.

***** Burlington Northern freight traffic estimate for the Donkey Creek to Edgemont rail segment in 1978 and 1982, personal communication, Jerrold G. Wood, Director of Public Works 1978.

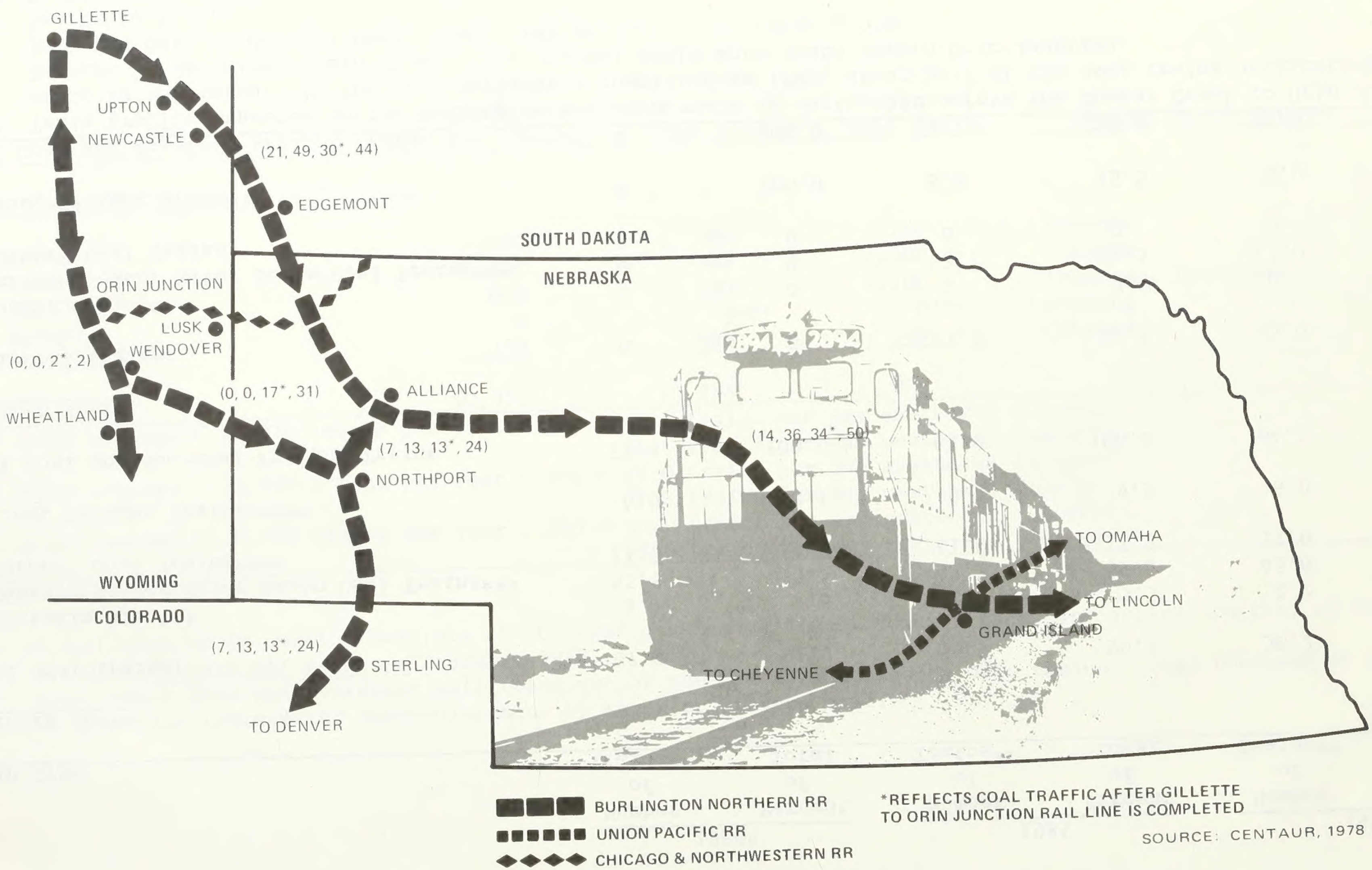


Figure R4-11
ESTIMATED DAILY COAL TRAIN TRAFFIC (1978, 1980, 1980*, 1985/1990)

permit faster train speeds, thus reducing the delay time at railroad crossings when trains travel through the town. No grade separations are currently planned. However, if train traffic increases much beyond 22 trains per day a structure separating a major highway from the railroad tracks would be needed (personal communication, Keith Newman, Torrington Chamber of Commerce, and John Lane, Wyoming State Highway Department 1978).

From Torrington, coal trains would continue east to Northport, Nebraska, thence east to Alliance or south to Sidney, Nebraska. While trains would bypass the town of Northport, they would pass through Sidney, causing vehicle delays at 10th and 13th streets. Beyond Sidney, in Sterling, Colorado, coal train traffic would merge with Union Pacific freight traffic. Sterling, therefore, represents a point, like Grand Island, where rail traffic impacts of Eastern Powder River Basin coal would become indistinguishable from other rail transport traffic.

Highways

Based on the 1975 rate of vehicle registration of 945 per 1,000 population, the projected number of registered motor vehicles in the eight northeastern counties of Wyoming would be 128,000 in 1980, 154,000 in 1985, and 172,000 in 1990. Increased road use would mean increased road maintenance and vehicle accident occurrences. Increased vehicle use would also result in increased noise levels, decreased air quality (due to dust and exhaust fumes), and increased wildlife and domestic animal road kills. (See Chapter 4, Air Quality and Wildlife.)

The roads that would be impacted the most are State Highways 59 and 387, U.S. Highway 14/16, the Reno Junction-Clareton Road, and Interstates 90 and 25. Substantial maintenance and upgrading of Highways 59 and 387 could be required to accommodate the projected traffic flow increases. The county road system would also be impacted by increased traffic flow.

See Chapter 8, Low-Level Scenario, for a description of highway improvements already planned.

Air Service

All seven commercial airports in northeastern Wyoming would experience increased passenger and freight traffic. The greatest impact, however, should occur at the Gillette-Campbell County Airport. There is a commuter airline service for the community of Gillette with daily flights to Casper, Douglas, Cheyenne, and Denver. However, no major commercial airlines serve Campbell and Converse counties, the closest commercial airline services being in Sheridan and Casper; this would mean increased use of the latter airports due to spillover effects from Campbell and Converse counties.

Total operations (takeoffs and landings) at the Gillette-Campbell County Airport in 1976 were 75,000 (personal communication, Sam Stafford 1977). Assuming use increases at the same rate as population, total operations would be approximately 152,000 by 1990. Another indicator of use is aviation fuel consumption. Whereas aviation fuel consumption has increased 30% each of the last 2 years in the state of Wyoming, it has increased 50% each of the last 2 years at the Gillette-Campbell County Airport. This emphasizes the particularly heavy impact which the Gillette-Campbell County Airport is already experiencing.

The Gillette-Campbell County Airport already is facing difficulties in meeting present demands on its facilities. Presently many passengers that want to land at Gillette are forced to land at either the Natrona County International Airport or the Sheridan County Airport and then rent cars and drive to the Gillette area. If major commercial airlines do begin to operate out of the Gillette-Campbell County facility, "noise pollution"in Gillette could become a problem.

Growth in air traffic at the Natrona County International Airport is shown in Table R4-12. Total operations have increased by 39,968 (71%) in the 4-year period from 1973 to 1977. Passenger and air freight totals show similar large increases from 1973 to 1976 of 53% and 26% respectively. By 1990, total operation at Natrona County International Airport would be 114,776 and total freight 4,760,316 pounds. This would mean a 20% increase in both total operations and in total freight from 1977 to 1990. In general, the Natrona County International Airport has excellent air facilities, not only to meet present but also future demands. Expansion and improvement have occurred regularly. Recently the runways were improved, and a planned $2 million terminal expansion is scheduled to begin in 1978. The only problem area is the water system, which is old and inadequate for both present and future needs (personal communication, John Martin 1977).

Increases in air traffic at the various airports could necessitate (1) possible additions to runways, and other facilities at the airports; (2) possible future relocation of the Gillette-Campbell County Airport and/or Converse County Airport; (3) increased potential for midair collisions and takeoff and landing accidents; (4) employment of additional personnel (flight service, maintenance, etc.); (5) increased noise levels; and (6) if services and facilities are improved and keep up with demand, improved air services for the region and the state of Wyoming. There is at present insufficient information available to predict potential magnitude of these impacts.

See Chapter 8, Low-Level Scenario, for a description of regional airport improvements already in progress.

Bus Lines

As populations increase, so would the use of bus services; however, the two bus companies servicing this region (Continental Trailways and Central Wyoming Transportation Company) anticipate no real problem in meeting future demands (personal communication, Ed Shilling, Trailways 1977).

TABLE R4-12

NATRONA COUNTY INTERNATIONAL AIRPORT

Year	Air Carrier*	Itinerate**	Local***	Total	Passengers****	Air Freight***** (Total pounds)
1973	10,058	28,452	17,542	56,052	132,991	2,424,747
1974	10,315	35,348	25,180	70,843	165,983	2,836,630
1975	10,519	37,418	19,394	67,331	185,113	2,997,030
1976	9,851	47,244	24,641	81,736	203,523	3,059,782
1977	9,548	53,978	32,494	96,020	234,026	3,977,716
1980	10,119	56,664	33,728	100,511	245,543	4,168,843
1985	11,486	64,326	38,289	114,103	278,748	4,732,582
1990	11,555	64,706	38,515	114,776	280,393	4,760,516

Source: Personal communication, John Martin 1977.

Note: Projections for 1980, 1985, 1990 are based upon population projections for Natrona County and assume the ratio between population in Natrona County and air operations in 1977 will remain the same in the future.

* Western and Frontier airlines
** Takeoff or landing by non-Casper-based aircraft
*** Takeoff or landing by Casper-based aircraft
**** Includes passenger arrivals and departures
***** Includes air freight received and sent

Pipelines

The proposed Panhandle Eastern Gasification Plant would require a 24-inch, 475-mile gas line. About 20 to 30 miles of this line would be in the Eastern Powder River Basin and would require 200 to 350 acres of land. It is expected that the line to supply water to the gasification plant would be 10 to 30 miles long and would require an additional 100 to 200 acres (Harbridge House 1976).

Additional pipelines might be necessary to handle increased natural gas or water needs for impacted communities. At present there is insufficient information to determine the magnitude of this possible demand.

Telephones

As population increases, so would the use of telephone services. By 1985, it is projected that the number of telephones in Campbell and Converse counties would double. However, a recently installed, very modern system in Gillette should handle anticipated future growth without any problems (personal communication, Ann Holmberg 1977). If necessary, a similar system could be installed in the Douglas-Glenrock area to handle service demands.

Electric Transmission Lines

Tri-County Electric Association has proposed a 230-kv transmission line to be built in cooperation with Pacific Power and Light Company (PP&L) from the Dave Johnston Power Plant near Glenrock to the area of Wyodak (with PP&L handling the Converse County portion, and Tri-County Electric Association the Campbell County portion). This 120-mile line could be constructed by 1980, if demand is sufficient, and it would occupy approximately 3,000 acres. When the line is built depends largely upon levels of regional development as its main function would be to supply power to coal mining operations. Additional lines could be necessary in the future to service energy-related needs.

SOCIOECONOMIC CONDITIONS

Sociocultural Impacts

Introduction

It is anticipated that traditional life-styles, attitudes, and values in northeastern Wyoming would continue to change, and that these changes would be reflected in a changing psychological environment. Any additional regional development that is unplanned in terms of avoiding and mitigating potential socioeconomic impacts would further complicate an already difficult situation.

Life-Styles, Attitudes, and Values

Traditional regional agrarian attitudes and values common in northeastern Wyoming are being challenged by characteristics (attitudes and values) related to boom-town conditions and by the process of industrialization. The potential for conflicts between the two sets of attitudes and values is great. (A detailed discussion of typical regional attitudes and values appears in Chapter 2, Socioeconomic Conditions.)

Many of the long-time residents may find population growth and the change to an industrial economic base to be frustrating--often disturbingly different from the small agricultural community life-style with which they are familiar. Often in boom employment situations, although many local residents do benefit directly through employment, there exists a segment of the population which for one reason or another (such as age or lack of specific skills) is unable to benefit through employment, but must either suffer the associated higher costs of the boom or be forced out of the area. Ranchers suffer in at least the short run, as the boom drives up their costs and reduces the availability of labor. There often is an associated increase in their land prices, but this can only help by giving the rancher more equity to borrow against or help his cash flow if he sells some of his land.

Newcomers, on the other hand, may find it difficult to fit into the established patterns of activity and the life-styles of the long-time residents. Many newcomers, especially the well educated, may dislike the isolation, the lack of services and culture, and the unfriendliness of some of the long-time residents. If local industry and services (such as medicine, housing, education, and recreation) cannot keep pace with energy industry growth, social difficulties in the region would be magnified for both current and new residents.

Psychological Impacts

Boom-town conditions may cause psychological impacts on some of the people within the region. Resulting problems include alcohol and drug abuse, single-car accidents, absenteeism from work, divorce, crime and delinquency, mental depression, suicide, and wife and child abuse. For example, the 1975 divorce rate in Campbell County was 42% higher than the state average, and in 1977, county child abuse case loads were the highest in the state (personal communication, Dr. Weiz, Northern Wyoming Mental Health Center 1977). Higher mental health hospital admission rates apparently correlate with those Americans that have migrated into one state from another (Locke and Duvall 1964). An estimated 70% of the construction workers in Campbell County are migrants from other states.

Psychological impacts can be reflected in lower corporate profits and regional coal production due to loss of worker productivity. In a study of boom towns by Gil-

more (1976), it was noted that coal output declined 25% to 40% in Rock Springs, Wyoming, between 1972 and 1974; in large part, this was attributed to a drop in worker productivity due to a high worker turnover rate and the subsequent need to train new employees.

The importance of human communication and interaction to mental health has long been accepted. Most new migrants to the region tend to be temporarily isolated from the general community, but isolation tends to severely impact families of construction and some mining workers who settle in mobile home parks.

Boomtowns are often not good places for wives. The wives of construction workers are mostly living in "aluminum ghettos"on the fringe of urban settlement. There are few jobs for women in construction work, and the support jobs don't increase as fast as the population. Activities— educational, social, and cultural— are limited, and there may be "cultural shock"for those who moved from large urban centers. Schools may be crowded and recreation limited for their children (Department of Housing and Urban Development 1976, p. 25).

The lack of local public transportation and limited mass transportation to regional trade centers increases family isolation.

Presently there is help available in Campbell County for mental health problems. In Gillette, the Campbell County Office of the Northern Wyoming Mental Health Center has been helping people with their problems and working with the community to improve the mental health climate since 1967. The center is presently staffed by four full-time mental health clinicians. Dr. Weiz, the coordinator for the center, feels that the center needs an additional three or four mental health clinicians, particularly in the area of crisis intervention (personal communication 1977). The office provides 24-hour telephone crisis service to connect a person in distress with one of the mental health clinicians. This "outreach"service is intended to counter the traditional "go it alone"western attitude that is often a barrier between those who need help and those who offer it.

If the local population doubles in the next 15 years, as is projected, mental health care would be inadequate. The degree of the population impact would be expected to create major problems in the short run; however, in the long run, the size of the problem would depend upon how much the mental health facilities are expanded and improved.

Economic Impacts

Introduction

Since many of the economic impacts of regional development in the Eastern Powder River Basin would affect neighboring counties, the economic analysis has been developed on the basis of an eight-county region. The eight-county region includes Campbell and Converse counties, as well as the neighboring counties: Crook, Johnson, Natrona, Niobrara, Sheridan, and Weston.

Additional information specific to Campbell County and Gillette can be found in Chapter 3, Socioeconomic Conditions, of the site-specific analysis.

Population

Table R4-13 contains local and regional cumulative population projections. The projections in Table R4-13 foresee a continued rapid growth in the population of Campbell County and Gillette between 1978 and 1990. During this period, Campbell County's population is anticipated to grow from 16,000 to 29,403, an average annual rate of change of 5.2%. Gillette, meanwhile, should grow from 10,067 to 23,322 inhabitants (an average 7.2% annual increase). Both the county and Gillette would experience their most rapid rate of annual population increase between 1978 and 1980 (6.5% and 9.1% per year respectively), declining gradually thereafter.

Converse County and the towns of Douglas and Glenrock would experience major population growth during the period under study, largely as a result of the projected coal gasification plant to be built northeast of Douglas. This population boom is expected to peak around 1985, when Converse County would have a population of 19,007 and Douglas would have 12,330 inhabitants. Thereafter, Converse County and Douglas both would face a decline in population as the coal gasification plant's large construction work force is disbanded and replaced with a smaller operating staff. Glenrock, where fewer of the gasification plant construction workers would live, would experience a somewhat slower population growth rate (5.2% annually between 1978 and 1990), but avoid a drop in population after the gasification plant is completed in 1985-1986. However, population growth in Glenrock would level off at only 0.3% annually between 1985 and 1990.

Crook and Weston counties, particularly the towns of Moorcroft (Crook) and Newcastle (Weston), would also experience significant population growth, since as much as one-third of the permanent work force in the Campbell and Converse County coal mines are expected to reside in those cities and commute to work. Like Campbell and Converse counties, the most rapid rate of increase in Moorcroft's and Newcastle's populations would occur between 1978 and 1980.

The continued steady expansion in the population of Casper (Natrona County) is attributable mainly to Casper's status as a regional trade center. Continued growth in the regional economy, mostly fueled by coal exports, would continue to enhance Casper's trade center status.

Sheridan County, particularly the city of Sheridan, would experience significant population growth between 1978 and 1990, although the local population growth rates would be slower than in Campbell and Converse counties and the town of Moorcroft. Population growth in Sheridan County would result primarily from a continuing influx of coal mine workers from neighboring areas of Montana, as well as from enlargment of Sheridan's present role as a secondary regional trade center.

TABLE R4-13

CUMULATIVE POPULATION PROJECTIONS, 1978-1990

County City	1978	1980	Annual Rate of Change* 1978-1980	1985	Annual Rate of Change* 1980-1985	1990	Annual Rate of Change* 1985-1990	Annual Rate of Change* 1978-1990
Campbell	16,000	18,142	(6.5)	24,181	(5.9)	29,403	(4.0)	(5.2)
Gillette	10,067	11,970	(9.1)	18,000	(8.5)	23,322	(5.3)	(7.2)
Other Areas	5,933	6,172	(2.0)	6,181	**	6,181	**	(0.3)
Converse	9,543	10,914	(7.0)	19,007	(11.7)	17,704	(-1.4)	(5.2)
Douglas	4,824	5,694	(8.6)	12,379	(16.8)	11,004	(-2.3)	(7.0)
Glenrock	2,296	2,733	(9.1)	4,138	(8.7)	4,210	(0.3)	(5.2)
Other Areas	2,483	2,487	**	2,490	**	2,490	**	**
Crook	5,148	5,438	(2.8)	6,319	(3.1)	6,837	(1.6)	(2.4)
Moorcroft	1,200	1,486	(11.3)	2,361	(9.7)	2,879	(4.1)	(7.6)
Other Areas	3,948	3,952	**	3,958	**	3,958	**	**
Johnson	6,803	6,862	(0.4)	7,212	(1.0)	7,624	(1.1)	(1.0)
Buffalo	4,400	4,455	(0.6)	4,799	(1.5)	5,211	(1.7)	(1.4)
Other Areas	2,403	2,407	**	2,413	**	2,413	**	**
Natrona	58,000	59,377	(1.2)	67,294	(2.5)	76,491	(2.6)	(2.3)
Casper	47,222	48,595	(1.4)	56,506	(3.1)	65,703	(3.1)	(2.8)
Other Areas	10,778	10,782	**	10,788	**	10,788	**	**
Niobrara	3,020	3,045	(0.4)	3,133	(0.6)	3,219	(0.5)	(0.5)
Lusk	2,000	2,021	(0.5)	2,103	(0.8)	2,189	(0.8)	(0.8)
Other Areas	1,020	1,024	**	1,030	**	1,030	**	**
Sheridan	22,501	23,713	(2.7)	27,347	(2.9)	31,666	(3.0)	(2.9)
Sheridan	13,400	14,608	(4.4)	18,230	(4.5)	22,549	(4.3)	(4.4)
Other Areas	9,101	9,105	**	9,117	**	9,117	**	**
Weston	6,932	7,493	(4.0)	8,315	(2.1)	8,976	(1.5)	(2.2)
Newcastle	3,455	4,012	(9.8)	4,828	(3.8)	5,489	(2.6)	(4.0)
Other Areas	3,477	3,481	**	3,487	**	3,487	**	**
Region	127,977	134,984	(2.7)	162,808	(3.8)	181,920	(2.2)	(3.0)

Source: University of Wyoming 1978.

* Average rate of change compounded annually.

** Average rate of change less than 0.1 %.

TABLE R4-14

CUMULATIVE EMPLOYMENT PROJECTIONS BY SECTOR

EIGHT-COUNTY REGION
1978-1990

	1978		1980		1985		1990	
	No.	% Total	No.	% Total	No.	% Total	No.	% Total
Agriculture	1,669	(3.3)	1,685	(3.1)	1,698	(2.7)	1,698	(2.5)
Minerals Extraction	9,064	(17.8)	10,935	(19.9)	12,045	(19.0)	12,882	(19.1)
Construction	4,167	(8.2)	4,633	(8.4)	6,249	(9.8)	4,843	(7.2)
Manufacturing	2,764	(5.4)	2,867	(5.2)	3,101	(4.9)	3,337	(4.9)
Railroads	182	(0.4)	321	(0.6)	608	(1.0)	660	(1.0)
Business/ Consumer Services	25,408	(50.0)	26,289	(47.9)	29,394	(46.3)	31,391	(46.5)
Government/ Education	7,575	(14.9)	8,093	(14.8)	10,422	(16.4)	12,624	(18.7)
Military	22	*	22	*	22	*	22	*
Total**	50,851	100.0	54,845	100.0	63,539	100.0	67,457	100.0

Sources: University of Wyoming 1978.
* Less than 0.1%.
** Totals may not add to 100.0% due to rounding.

TABLE R4-15

CUMULATIVE EARNINGS PROJECTIONS BY SECTOR

EIGHT-COUNTY REGION
(MILLIONS OF 1975 DOLLARS)

	1978		1980		1985		1990	
	Dollars	% Total	Dollars	% Total	Dollars	% Total	Dollars	% Total
Agriculture	15.2	(2.4)	17.7	(2.4)	18.8	(1.9)	19.9	(1.6)
Minerals Extraction	142.2	(22.5)	184.2	(25.3)	242.2	(24.7)	308.0	(25.4)
Construction	84.0	(13.3)	98.4	(13.5)	154.0	(15.7)	136.4	(11.2)
Manufacturing	41.4	(6.6)	44.4	(6.1)	52.8	(5.4)	62.5	(5.1)
Railroads	2.7	(0.4)	4.9	(0.7)	10.6	(1.1)	13.1	(1.1)
Business/ Consumer Services	165.6	(42.1)	187.6	(39.5)	364.8	(37.3)	468.8	(38.6)
Government/ Education	79.5	(12.6)	90.1	(12.4)	135.4	(13.8)	205.4	(16.9)
Military	0.4	(0.1)	0.4	(0.2)	0.5	(0.1)	0.6	(0.1)
Total*	631.1	(100.0)	727.7	(100.0)	979.1	(100.0)	1,214.7	(100.0)

Source: University of Wyoming 1978.
* Totals may not add to 100.0% due to rounding.

After a short period of relatively rapid population growth rate (5.6% annually) between 1976 and 1978, population growth in Johnson County is anticipated to diminish to an average rate of only 1.0% annually between 1978 and 1990. Niobrara County is likewise expected to experience only nominal growth (0.5% annually).

Employment

Table R4-14 contains cumulative employment projections for the eight-county region. Summarizing, business and consumer services would remain the predominant source of employment through 1990, although their percent share in total employment should decline somewhat during this period (i.e., from 50.0% to 46.5%). Primarily under the influence of coal development, minerals extraction is projected to increase its relative share in total employment between 1978 and 1980 (i.e., from 17.8% to 19.1%). While declining in its relative share of total employment after peaking in 1980, mining employment is projected to show continued moderate growth in absolute terms through the end of the decade. Construction employment should peak in 1985 due to the projected construction of a gasification plant in Converse County, then decline in both relative and absolute terms through 1990. Among the other sectors of the regional economy, agriculture should continue to decline in relative importance as a source of employment through 1990, from 3.3% in 1978 to 2.5% by 1990. Manufacturing is projected to decline from 5.4% to 4.9% of total employment during the period under study. Railroad employment would increase slightly, from 0.4% to 1.0% of regional employment. Government employment should show considerable absolute and relative increases (from 14.9% to 18.7% of total employment).

These projected regional developments would be mirrored to varying degrees among the individual counties. In most counties, business and consumer services would occupy a less important role in the local economy than they do in the region as a whole; this discrepancy is attributable to the preponderance of business and consumer services in Casper and Sheridan, which account for most of the region's employment in these sectors. However, business and consumer services are projected to remain the most important source of employment in every county except Converse and Crook, where this sector would be supplanted by mining before 1985. Campbell and Johnson are the only counties in which construction is projected to consistently exceed 10% of total employment. However, due to the construction of a gasification plant northeast of Douglas, construction would peak sharply at nearly 30% of total Converse County employment in 1985. Manufacturing employment would be concentrated in Natrona County throughout the period until 1990, offsetting the relatively low levels of manufacturing employment in the other counties. Government/education would be a major source of employment in all counties, particularly Sheridan (where it constitutes between one-fourth and one-third of county employment in the period under study). Finally, agricultural employment would show a steady decline in relative terms in all counties through 1990.

Income

Table R4-15 contains cumulative earnings projections for the eight-county region. Total earnings in the region would be expected to rise from $631.1 million in 1978 to $1,214.7 million in 1990, an increase of 92.5%. (All figures are expressed in 1975 equivalent dollars.) It is anticipated that business and consumer services would remain the predominant source of earnings in the region as a whole through 1990, followed in second place by minerals extraction. However, business and consumer services would be expected to decline from 42.1% of total regional earnings in 1978 to 38.6% in 1990, while minerals extraction should increase from 22.5% to 25.4% of total earnings between 1978 and 1990. Construction should continue as the third largest source of regional earnings at least through 1985 (when it should account for 15.7% of total earnings), then decline to 11.2% as planned energy construction projects are completed. By 1990, government/education would have replaced construction as the third largest source of regional earnings, contributing 16.9% of the total. Agriculture would continue to decline in relative importance, from 2.4% of regional earnings in 1978, to 1.6% in 1990. Manufacturing is likewise projected to continue its decline in relative importance as a source of regional earnings between 1978 and 1990, from 6.6% to 5.1%.

Trends in projected earnings on the individual county level would mirror these regionwide developments to varying degrees. Minerals extraction, rather than business and consumer services, is projected to contribute the largest share of total earnings in Campbell, Converse, Crook, and Weston counties throughout most of the 1978-1990 period. Business and consumer services would be the largest source of earnings in the other four counties (Johnson, Natrona, Niobrara, and Sheridan), with shares ranging from 37.1% of total earnings (Johnson) to 50.2% (Natrona). Construction is expected to rank as the third largest source of earnings in Campbell and Johnson counties until 1985, after which it would be supplanted in third place by government/education. In the remaining six counties, government/education generally would remain third in terms of its relative contribution to total earnings throughout the period under study.

Among other sectors, manufacturing should decline as a proportion of total earnings in every county except Niobrara between 1978 and 1990. Despite a relative decline in manufacturing earnings in both cases, Natrona and Weston counties would remain the only counties which receive more than 10% of total earnings from manufacturing through 1990. Agriculture would continue its across-the-board decline as a relative source of earnings between 1978 and 1990.

Local Services

The impact of projected cumulative population growth on local services would vary widely among individual communities, depending on current service levels and capacity of facilities, as well as the rate and magnitude of expected population growth. Public services and facilities in a number of communities in the eight-county region would be overloaded. In the short term, such adverse impacts would constitute a hardship for all those involved in the growth process.

Projected service levels in individual communities are compared in the following discussion with commonly accepted service standards in order to obtain an assessment of probable impacts. While easily quantifiable, however, such yardsticks afford only a limited measure of the impact of development upon residents' lives.

Perhaps the simplest example is fire protection: while inadequate fire protection may or may not actually lead to a sudden rash of highly destructive fires, it will certainly lead to a deterioration in local fire insurance ratings and an increase in the insurance premiums of local residents and businesses. Inadequate police coverage may lead to an increase in the incidence of crime and/or traffic problems; whether or not these problems occur, apprehension and insecurity may increase among many local residents, for whom the police officer on patrol is a readily visible source of reassurance.

An inadequate water supply or treatment facility may result in insufficient water pressure (which may also impede fire fighters and lower insurance ratings), rationing of available water supplies, and unpleasant-tasting drinking water. Substandard sewage treatment facilities can cause pollution of nearby waterways and create disagreeable smells, and in extreme cases they may have to be shut down by the state or the Environmental Protection Agency.

In all cases, local residents must pay the cost of programs to ameliorate these conditions (e.g., hiring new policemen, expanding sewage treatment facilities), although financial assistance may be available from outside sources. (See discussion of local community finances.) However, to the extent that the local communities can finance the needed expansion and improvement of services, these services should begin to catch up with the population. In the long term, more and better services should be available to all.

County Services. Generally, the county sheriffs are responsible for providing police protection to rural, unincorporated areas. Major problems common to all counties include insufficient manpower and slow response times to calls, both of which are largely the result of the long distances to be covered. Most of the recent population growth has occurred in the incorporated areas; however, there has been some spillover of population, and hence increased crime, into rural areas. While the rural population would be expected to increase only slightly by 1990, this spillover effect may intensify as the urban population grows. Thus, the current manpower shortage felt by county law enforcement agencies would probably be more acutely felt in the future. (The lack of published standards for rural law enforcement agencies makes it difficult to estimate the number of additional officers and vehicles required to adequately meet present or future law enforcement needs in rural areas.)

The lack of standards or planning guidelines also makes it difficult to assess the additional manpower and equipment needed to serve current and projected rural fire protection needs. However, these needs are not expected to increase significantly, since most additional residential development would be expected to occur in incorporated areas. In addition, rural residential (as opposed to brush) fire protection in most counties (except Johnson, Natrona, and Sheridan) is provided by a joint municipal/county fire department or the municipal fire departments themselves. The latter are evaluated below with respect to municipal fire protection requirements, which constitute their major area of responsibility.

Gillette. The Gillette Police Department would be expected to require at least 12 additional officers by 1990 (for a total force of 38), plus 3 additional patrol cars (making a total of 13 cars). Planned expansion of the municipal water supply would alleviate the city's fire-fighting deficiency, but the fire department would need an additional pumper truck of at least 500-gallon-per-minute (gpm) capacity by 1990. To ensure adequate manning levels, the fire department should also obtain 5 additional full-time firemen or 15 volunteers by 1990.

The city's projected water supply, augmented by water from the Madison Formation, should be adequate to meet the needs of the projected cumulative population through 1990. However, the city would need to expand its water treatment capacity from the present level of 2.5 million gallons per day (mgd) to over 10 mgd. Gillette's current sewage treatment capacity (1.4 mgd) would have to be expanded to some 4.0 mgd by 1990 to meet projected needs.

Douglas. Douglas would be faced with the problem of planning services capable of meeting the temporary needs of over 12,300 people by 1985, but which would not represent excessive capacity when the population declines to under 11,000 by 1990. Meeting the police protection requirements of the peak 1985 population would require hiring an additional 10 police officers (making a total of 21), as well as purchasing 4 more police cars (making a total of 7). Since the 1990 requirement would call for a reduced total of 19 officers and 6 patrol cars, the city might meet the peak 1985 demand through a joint-powers or manpower sharing arrangement with neighboring law enforcement agencies, and simply defer routine replacement of an old patrol car beyond the 1985 population "hump"

Douglas' fire-fighting capacity would be sufficient to meet projected requirements through 1990, particularly given the availability of several county-owned fire trucks which are garaged in Douglas. However, the fire department would need up to 60 additional volunteer firemen to properly man the available equipment.

With currently planned expansion, Douglas' water supply would reach 4.0 mgd by 1980. Projected demand would outstrip capacity between 1980 and 1985, reaching a peak of 5.6 mgd by 1985. Douglas' lagoon sewage treatment facility is already inadequate by Environmental Protection Agency standards; meeting the projected 1985

peak demand would require building a new 2.1-mgd facility by 1985.

Glenrock. By 1985, the Glenrock Police Department would require 6 additional officers (making a total of 13) and 2 more patrol cars (a total of 5); no further increases should be necessary before 1990. The combined fire-fighting capacity provided by town-owned pumper trucks and county pumpers stationed in Glenrock should be adequate through 1990. However, up to 15 additional volunteer firefighters would be needed. Glenrock's current water supply and sewage treatment capacity, combined with planned increases in the water supply, should be adequate through 1990.

Moorcroft. Meeting projected law enforcement requirements would require that, in addition to the current force of 3 police officers, the Moorcroft Police Department hire 2 police officers between 1980 and 1985, plus 1 more by 1990. Adding 3 officers to the force would also require purchasing at least 1 additional patrol car between 1980 and 1985 to ensure adequate mobility. In order to provide adequate fire protection, the Moorcroft Fire Department should purchase an additional pumper truck by 1990, and recruit an additional 45 volunteer firemen.

Compared with the current 300,000-gallon-per-day (gpd) peak water supply capacity, Moorcroft would need to expand its water supply to a maximum of 670,000 gpd by 1980, one million gpd by 1985, and 1.3 million gpd by 1990. Moorcroft's sewage treatment capacity, which is adequate to meet the demands of the current population, would have to be expanded to a capacity of 475,000 gpd by 1990.

Buffalo. The Buffalo Police Department would need up to 4 additional police officers by 1990 (bringing its total strength up to 11 officers), plus 1 more patrol car (making a total of 4 vehicles). In order to provide adequate fire protection for the projected population, the Buffalo Fire Department would require an additional 1,000-gpm pumper truck, and should recruit an additional 43 volunteer firemen.

Buffalo's water supply would be sufficient to meet the needs of the projected population through 1990. However, Buffalo would have to increase its sewage treatment capacity, which is inadequate to serve the needs of the present population, to at least 875,000 gpd by 1990.

Casper. To maintain acceptable levels of police protection, Casper would have to hire at least 29 more police officers by 1990, and purchase 8 more patrol cars (for a total of 99 officers and 27 patrol cars). While the Casper Fire Department would not require any additional fire trucks between 1978 and 1990, up to 25 additional fireman should be hired to maintain current service levels. Casper's current peak water supply is approximately 35 mgd, which should be adequate to meet the demands of the projected population through 1989, with a supply shortfall of 1.0 mgd by 1990 unless new supplies are provided. The city's 6.5-mgd sewage treatment plant is currently operating at near maximum capacity, and would have to be expanded to an 11-mgd capacity by 1990 to meet the demands of the projected population.

Lusk. Lusk's current police manpower and equipment levels would be sufficient to meet projected needs through 1990. However, the fire department should acquire an additional 750-gpm to 1,000-gpm pumper, as well as recruit an additional 20 volunteer firemen. Lusk's water supply should be adequate through 1990. However, the city would need to replace its current sewage treatment facility with a 22-acre lagoon system to meet the projected demand through 1990.

Sheridan. To meet demands of the projected population, Sheridan should increase its police force by at least 11 officers by 1990 (a total of 39 officers) and acquire 4 additional patrol cars. The manning and equipment of the Sheridan Fire Department should be adequate through 1990.

Sheridan's current water supply capacity of 10 mgd should be adequate to meet the needs of the population until 1990, when the projected demand would reach 10.2 mgd. The maximum design capacity of the city's sewage treatment plant (5.0 mgd) should be adequate through 1990, provided technical problems currently being experienced can be solved.

Newcastle. The Newcastle Police Department would require at least 2 additional officers by 1990 (a total of 11), plus 1 additional patrol car (a total of 4). An additional 500-gpm pumper truck, plus up to 60 additional volunteer firefighters, would be necessary to meet projected fire protection requirements through 1990.

The ability of Newcastle's water supply to meet future demands would depend on the yield of a fourth well to be completed in mid-1978, but the combined output of the four city wells probably would not exceed 4.4 mgd, or 300,000 gpd less than the 1990 projected requirement. Newcastle's present lagoon would have to be supplanted by facilities capable of treating approximately 900,000 gpd by 1990.

Housing

Table R4-16 shows projected cumulative growth of housing demand in local housing markets, compared with historical growth rates in the housing stock. The projected annual growth in demand for single-family housing varies from a low of 0.3% in Buffalo to a high of 8.9% in Moorcroft. In Gillette, the demand for single-family housing would be expected to grow at a rate of 6.4% annually between 1977 and 1990. The demand for single-family housing in Douglas and Glenrock is projected to grow at average annual rates of 3.6% and 4.6% respectively. Based on comparisons with historical rates of growth in the local stock of single-family housing, the local housing market should be able to meet the additional population demand for single-family homes through 1990, since the latter is generally expected to grow at a slower rate than the historical growth in the single-family housing supply. This conclusion is strengthened by the fact that the local housing market by 1978 had largely overcome two obstacles (i.e., uncertainties regarding the extent of future coal development and the absence of a well-developed local housing construction

TABLE R4-16

PROJECTED CUMULATIVE HOUSING DEMAND
1978-1990

Community/ Housing Type	1977 Housing Stock	Average Annual Growth Rate of Housing Stock, 1970-77**	Additional Demand for Housing Unit: 1977-1990 Total No. of Units	Additional Demand for Housing Unit: Average Annual Growth of Housing Stock Required, 1977-90**
Gillette				
Single Family	1,623	5.2%	2,007	6.4%
Multi-Unit	680	6.3	513	4.4
Mobile	1,542	13.3	1,573	5.6
Total all types	3,845	8.1	4,093	5.7
Douglas				
Single Family	1,232	6.5	728	3.6
Multi-Unit	207	0.7	353	8.0
Mobile	349	24.8	1,228	12.3
Total all types	1,788	8.2	2,309	6.6
Glenrock				
Single Family	439	NA	318	4.3
Multi-Unit	63	NA	162	10.3
Mobile	159	NA	569	12.4
Total all types	661	3.7	1,049	7.6
Moorcroft				
Single Family	147	NA	296	8.9
Multi-Unit	0	NA	65	0
Mobile	150	NA	233	7.5
Total all types	297	NA	594	8.8

TABLE R4-16
(cont'd)

PROJECTED CUMULATIVE HOUSING DEMAND
1978-1990

Community/ Housing Type	1977 Housing Stock	Average Annual Growth Rate of Housing Stock, 1970-77**	Additional Demand for Housing Unit: 1977-1990 Total No. of Units	Additional Demand for Housing Unit: Average Annual Growth of Housing Stock Required, 1977-90**
Buffalo				
Single Family	1,398	4.8%	55	0.3%
Multi-Unit	93	-12.0	44	3.0
Mobile	130	11.4	164	6.5
Total all types	1,621	3.3	263	1.2
Casper				
Single Family	12,034	2.3	1,840	1.1
Multi-Unit	3,580	3.0	963	1.8
Mobile	655	18.1	3,142	14.5
Total all types	16,269	2.8	5,945	2.4
Lusk				
Single Family	NA	NA	17	NA
Multi-Unit	NA	NA	22	NA
Mobile	NA	NA	93	NA
Total all types	720	0.2	132	1.3
Sheridan				
Single Family	3,993	2.1	600	1.1
Multi-Unit	477	-3.0	421	5.0
Mobile	780	45.7	1,563	8.8
Total all types	5,250	2.4	2,687	3.2
Newcastle				
Single Family	950	0.4	369	2.6
Multi-Unit	246	6.1	81	2.2
Mobile	172	9.9	242	7.0
Total all types	1,368	1.6	592	2.8

TABLE R4-16
(cont'd)

PROJECTED CUMULATIVE HOUSING DEMAND
1978-1990

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* Two major factors were taken into account in compiling Table R4-16: workers' personal preferences for different types of housing (Table R2-32) and their ability to pay for the type of housing desired (Table R2-34). First, housing preferences of the incremental population were estimated by occupational group, using the percentages in Table R2-32. The only exception is, that after 5 years' local residence, newcomers' housing preferences are assumed to be the same as those of long-term residents.

Effective demand for different types of housing (consisting of households desiring and able to afford a particular type of housing) was then calculated for each occupational group using the bankers' rule of thumb that a family's monthly housing expenditures should not exceed 25% to 33% of its monthly income. According to Table R2-34, in the future, only households headed by mining and construction workers will be able to afford single-family housing, or households with multiple wage earners. Projections of the number of mining and construction workers were obtained from employment projections in Table R4-14, and the number of households with multiple wage earners was estimated based on data in the <u>1970 Census of Population</u> for Wyoming (U.S. Department of Commerce 1970).

Households desiring, but unable to afford, single-family housing were allocated to mobile housing units.

** Average rate of change, compounded annually.

NA = not available

industry) which inhibited single-family home construction in the early 1970s (Denver Research Institute 1977).

However, Table R4-16 measures only effective demand, i.e., households desiring *and* able to afford the high cost of single-family housing. Many other households (mainly those with single wage earners employed in occupations other than the relatively high-paying mining and construction sectors) would prefer single-family homes, but would have to settle for lower-cost multi-unit or mobile housing. In communities like Gillette, Douglas, Glenrock, Moorcroft, and Newcastle, where a large percentage of the new arrivals would be employed in the high-paying mining and construction sectors, the majority (i.e., 60%-70%) of households desiring single-family housing could afford it. In other communities, where a smaller percentage of the new residents would be mining or construction employees, and where there would be fewer multiple wage-earner households, as many as 50%-80% of the households desiring single-family housing by 1990 would be unable to afford it. The resultant disappointment and frustration among would-be homeowners is a significant adverse impact of rapid population growth in these communities.

Alongside those households forced to accept multi-unit or mobile housing by high single-family home costs are those households for whom multi-unit or mobile homes would be the preferred housing mode. (This group includes particularly transient construction workers.) A great increase in demand between 1977 and 1990 for multi-unit and mobile housing accommodations would be expected in certain communities, particularly Gillette, Douglas, Casper, and Sheridan. However, sufficient growth in the multi-unit and mobile housing market to meet projected demand is not assured. Potential obstacles include the relatively high business risks associated with either multi-unit housing projects or mobile home parks in the region, and the local shortage of commercial credit. These factors would discourage some developers and make it difficult for others to obtain needed bank credit. Some local officials, bankers, and residents are also unsympathetic to the need for additional mobile home parks, rendering it difficult to obtain land for additional mobile home lots (Denver Research Institute 1977). A solution to these interrelated problems—the high cost of single-family housing, and the limited range of housing alternatives available—would be a precondition if the region's housing needs are to be met adequately. Several policies are already in effect to alleviate these housing problems. Some coal companies, for example, have played active roles in developing subdivisions (e.g., the community of Wright in Campbell County), and in some cases they have even subsidized a portion of the cost of this housing. The state of Wyoming, through the Wyoming Community Development Authority, also has a program to make mortgage funds available at a reduced rate. These, and similar programs, would have the potential to ease the critical local housing situation.

Education

The following section discusses projected school district enrollments for the eight-county region (see Table R4-17). The most significant impacts would be experienced in the Gillette, Douglas, Casper, and Sheridan school districts.

In the Gillette School District, current building capacity plus planned expansions would bring total district capacity to 6,921 pupils by 1982, which is sufficient to meet projected enrollment increases through 1985. However, by 1990 an additional 775 junior/senior high school spaces, plus 600 more elementary spaces would be needed. The district would also need to hire an additional 261 teachers by 1990 in order to maintain current pupil/teacher ratios.

In Douglas, current plus planned building capacity would only be adequate through 1981, after which capacity must be expanded by an additional 1,440 spaces to meet the 1985 peak demand. Since long-term projections show cumulative enrollment declining to 3,698 by 1990, the school district might elect to meet at least part of the additional demand through the use of portable or temporary classrooms, utilization of other community facilities (e.g., library meeting rooms, church halls), subdividing existing classrooms with room dividers, or busing children. The district would also require approximately 125 additional teachers by 1985, of whom only 100 would need to be long-term appointments in view of the projected enrollment decline after 1985.

Despite an active building program which would bring Casper's total district capacity to 15,011 pupils by 1982, projected continued enrollment growth would require that Casper provide for an additional 3,200 pupils by 1990. The requirements would probably include at least four new elementary schools, a new junior high school, and additions to one or both of the existing high schools. The district would also require an additional 200 teachers by 1990.

Sheridan's current plus planned facilities should be augmented by 1,741 spaces by 1990. Needed facilities would probably include three more elementary schools plus a new junior high or high school. Sheridan would also need at least 114 new teachers by 1990.

The remaining school districts should be able to meet projected cumulative enrollment increases without major capital investments beyond those currently planned, through building additions and the use of modular or temporary classrooms. While most would have to hire some additional teachers, the required increases would be relatively small.

Health Care

Chapter 2 discussed the shortage of health care personnel in most local communities. Unless these communities have significantly greater success in attracting and holding new medical specialists, this shortage would be aggravated by projected population increases.

Table R4-18 projects the number of additional physicians, registered nurses, and dentists required to provide

TABLE R4-17

PROJECTED CUMULATIVE SCHOOL DISTRICT ENROLLMENTS
1980-1990

	1980				1985				1990			
	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total
Campbell												
Gillette	2,895	1,161	1,059	5,116	3,892	1,561	1,423	6,877	4,693	1,882	1,716	8,292
Converse												
Douglas	1,258	461	410	2,151	2,410	923	787	4,121	2,163	826	706	3,698
Glenrock	509	240	216	965	709	335	302	1,346	719	340	306	1,366
Crook												
Sundance	713	359	335	1,408	829	417	389	1,637	897	451	421	1,771
Johnson												
Buffalo	763	334	324	1,420	802	351	340	1,493	847	371	360	1,578
Natrona												
Casper	7,320	3,307	3,505	14,132	8,296	3,748	3,972	16,016	9,430	4,260	4,515	18,205
Niobrara												
Lusk	304	155	161	621	312	160	166	639	321	164	171	656
Sheridan												
Ranchester	361	188	189	738	362	189	189	740	361	191	189	742
Sheridan	2,009	961	872	3,842	2,507	1,199	1,080	4,794	3,102	1,483	1,385	5,930
Clearmont	89	21	34	144	89	22	34	145	89	22	35	146
Weston												
Newcastle	713	324	353	1,390	792	360	391	1,543	859	390	426	1,675
Upton	245	109	104	458	272	121	116	509	291	129	124	544

Source: Based on University of Wyoming (1978) WRRI model projections.

TABLE R4-18

PROJECTED HEALTH CARE PERSONNEL REQUIREMENTS

	1977 Physicians	Physicians Recommended Levels*			1977 Registered Nurses	Registered Nurses Recommended Level**			1977 Dentists	Dentists Recommended Level***		
		1980	1985	1990		1980	1985	1990		1980	1985	1990
Campbell	9	18	24	29	53	63	84	101	4	11	15	18
Converse	6	11	19	18	29	38	67	62	2	7	12	11
Crook	2	5	6	7	11	19	22	24	1	3	4	4
Johnson	4	7	7	8	30	24	25	27	2	4	5	5
Natrona	80	59	67	76	383	208	236	268	34	37	42	48
Niobrara	2	3	3	3	12	11	11	11	1	2	2	2
Sheridan	26	24	27	32	154	83	96	111	16	15	17	20
Weston	3	7	8	9	26	26	29	31	2	5	5	6
Region	132	135	162	181	698	473	570	636	62	84	101	113

Source: Wyoming Department of Health and Social Services 1977; personal communication, Larry Bertilson, State Health Planning Manager 1978.

* Based on recommended standard of 1,000 persons per physician.

** Based on recommended standard of 285 persons per registered nurse.

*** Based on recommended standard of 1,600 persons per dentist.

recommended levels of health care to the local population through 1990. According to the table, the region would need an additional 49 physicians and 51 dentists by 1990, while there would be a surplus of 62 registered nurses. On the individual county level, Natrona is presently the only county with enough doctors to serve the projected needs of the population through 1990. Johnson, Niobrara, and Sheridan counties have sufficient registered nurses (but not doctors or, with the exception of Sheridan, dentists) to meet their requirements through 1990. Campbell, Converse, Crook, and Weston counties would face continuing deficiencies in all three major health care personnel categories unless they can attract additional doctors, dentists, and nurses.

Hospital bed needs in the region are more difficult to project on a county-by-county basis. The role of the 297-bed Natrona County hospital as a regionwide health center and the fact that many area residents cross county lines to obtain hospital service make it necessary to address hospital needs on a regionwide basis. Present hospital facilities as well as those either under construction or planned should be sufficient to meet the projected demands of the population through 1980. By 1985, however, the region would need 114 additional hospital beds, increasing to 196 beds by 1990. These needs could be met through new hospital construction or, if possible, by increasing the presently low average utilization rate of existing bed facilities (see Chapter 2).

Retail Trade

If it is assumed that future per capita retail expenditures (measured in constant 1975 dollars) in the eight-county region would continue to grow at the historical rate of 0.7% annually through 1990 (see Chapter 2), then total 1990 retail sales in the region are projected at approximately $660 million (1975 dollars), a 74% increase since 1975.

Natrona County (i.e., Casper) would be expected to continue as the region's principal trade center through 1990. Natrona County captured more than half of all new retail trade in the eight-county region between 1972 and 1977. However, the growth of other, secondary trade centers (particularly in neighboring Converse County, which is expected to undergo rapid growth in the next decade), should reduce Natrona County's relative attractiveness as a trade center in future years. Taking this into account, total 1990 retail sales in Natrona County are estimated at $278 million (1975 dollars), or approximately 42% of total regional sales.

In recent years, Campbell County (Gillette) and Sheridan County (Sheridan) have emerged as secondary trade centers in their own right. Between 1972 and 1977, both enjoyed shares in regional sales approximately proportional to their respective shares in regional population. On a similar basis, 1990 retail sales in Campbell County are estimated at $105 million (1975 dollars), compared with $115 million (1975 dollars) in Sheridan.

Population projections suggest that Converse County by the mid-1980s may also attain the status of a secondary trade center, capable of providing for the greater part of its residents' needs and drawing shoppers from neighboring counties. As such, Converse County may expect annual retail sales up to $60 million (1975 dollars) by 1990, concentrated in the towns of Douglas and, to a lesser extent, Glenrock.

Local Finances

Projected population increases, together with coal and other related development, would increase the revenues at the disposal of local governments, while simultaneously increasing their operating and capital outlay requirements. It is possible for local governments to run with short-term deficits, but in the longer term they must balance revenues and expenditures. If anticipated revenues are insufficient to cover expected costs, either additional sources of funds must be found, or planned expenditures must be scaled down.

Principally due to the large property tax base at their disposal, local county governments and school districts should be able to meet the service and educational requirements of the projected population through 1990. For municipal governments, the outlook would be mixed. Most municipalities are expected to be able to meet their projected long-term operating requirements without seeking major additional outside funding or cutting back on expenditures.

Those municipalities which would face potential operating deficits without the injection of new local or outside funds or spending cutbacks include Douglas, Glenrock, and Moorcroft. Douglas would face a maximum operating shortfall of $1 million by 1985, while Glenrock and Moorcroft would face smaller potential annual operating shortfalls of $50,000 and $25,000 respectively by 1990. The opportunities for Douglas and Glenrock to raise additional local revenues by levying additional taxes would be rather limited since Converse County already levies the optional 4% sales tax and neither city can increase its general purpose property tax levies much more due to legal limitations. Addition of the 4% optional sales tax in Crook County would help redress Moorcroft's prospective operating shortfall. Otherwise, these communities would have to either turn to the state or federal governments for financial assistance or cut back on service levels in order to avoid chronic operating deficits.

Municipal governments also vary in their ability to meet the capital costs of additional facilities requirements. Serious problems would occur in Gillette, which, while able to meet projected future operating costs, would face at least a $7 million capital deficit by the early 1980s. Douglas would face capital requirements of up to $5 million in excess of its legal bonding capacity, depending on the type of sewage treatment facility built. Moorcroft would have to raise some $500,000 for needed water and sewer system improvements, while needed improvements in Buffalo's and Newcastle's water and sewage systems might cost each town up to $3 million, depending on the type of sewage treatment facility provided. Casper would require $8.0 million for needed expansion of its water supply and sewage facilities.

Expenditures of this magnitude would be beyond local financing capabilities through either current revenues or bonded debt. Possible outside sources of financial assistance include state coal tax funds, the U.S. Farmer's Home Administration, or Environmental Protection Agency, as well as the private coal companies.

CHAPTER 5

UNAVOIDABLE ADVERSE IMPACTS OF CUMULATIVE REGIONAL DEVELOPMENT

The following impacts would remain after application of the planning and environmental controls discussed in Chapter 3. Whether certain impacts (such as those related to visual resources or socioeconomics) are adverse is a matter of personal preference. To the long-time resident who cherishes a traditional life-style, change probably would be adverse. To new residents, and those interested in economic and urban development, signs of growth would likely be welcome. This chapter is developed as a summary, and the reader is therefore referred to Chapter 4 for more detailed discussion of impacts.

By 1990, a total population increase of 22,000 in Campbell and Converse counties is expected over the 1978 level of 25,500. The following impacts would result; they would be felt most strongly in the municipalities of northeastern Wyoming: (a) annual operating budget shortfalls of $1 million in Douglas by 1985 and $50,000 in Glenrock and $25,000 in Moorcroft by 1990; (b) capital budget shortfalls of $7 million in Gillette by the early 1980s, $5 million in Douglas by 1985, and lesser amounts in smaller communities; (c) continued high housing costs and shortages of rental units which would force people to accept housing they do not like; (d) temporary shortfalls in health services, classroom space, numbers of teachers, police and fire protection, and water and sewer services (see Chapter 4)—provision of additional facilities and manpower would depend on solution of budget problems; (e) unavoidable sociological impacts relating to family problems, child abuse, and mental health—these impacts would be felt particularly in Gillette, Douglas, and Moorcroft which would experience annual rates of population change between 1978 and 1990 of 7.2%, 7.0%, and 7.6% respectively; and (f) loss of the traditional regional agricultural life-style.

Coal train traffic would be increased by an estimated 241 unit trains per week (one way) along the main regional rail routes by 1990. Coal traffic in 1978 amounts to 60 unit trains per week (one way). Impacts of rail traffic, such as noise and delays at crossings, would be quadrupled by 1990. Predicted 1990 coal train traffic is approximately 62% more than present track capacity. Completion of the rail line from Donkey Creek to Orin Junction in mid-1980 would approximately double track capacity. However, by 1990 coal train traffic would amount to approximately 82% of track capacity; total (coal plus other freight) train traffic would approximately equal track capacity.

The number of registered motor vehicles in Campbell and Converse counties would increase from about 24,000 in 1978 to about 45,000 in 1990. The number of vehicles registered in 1978 in these counties is about 24,000. Increased road use would mean increased maintenance costs and vehicle accident rates.

When aquifers are disrupted by mining, lowering of water levels would occur in the overburden, coal, and some deep aquifers in the vicinity of mines and would possibly dry up some springs and seeps while reducing streamflow in areas around mines. The extent of the cones of depression around the mined areas would depend on aquifer properties and time. Local areas in southeast Campbell County would change from groundwater recharge to discharge areas during the time of mining.

Water in aquifers which develop after reclamation would be of poorer quality than in the premining aquifers. "Water in spoils was found to be significantly more highly mineralized than natural groundwater in terms of total dissolved solids, calcium, magnesium, and sulfate,"according to Rahn (1976, p. 54). Such water may exceed levels recommended for drinking water and irrigation.

Municipal water use would increase from 6,650 acre-feet annually in 1978 to 10,260 acre-feet annually in 1990. Additional water use is anticipated for industrial uses such as secondary and tertiary oil recovery, uranium milling, and coal conversion, as well as for agricultural needs for irrigation and domestic water. Total water use in the region by 1990 is expected to reach 70,450 acre-feet annually, or an increase of 20,930 acre-feet annually over 1978 levels. Increased water use would affect mostly population centers. Short-term water shortages could occur until the need for the water is eliminated or alternate sources are found. Such shortages would be most likely in Douglas, Gillette, Moorcroft, and Newcastle and would range (without expansion of present treatment plants) from 300,000 gallons per day to 7.5 million gallons per day.

Water pollution, a combination of hundreds of possible contaminants, which may result from increased population and industry may have an indeterminate adverse impact on public health. Some of the factors which would affect the scale of the impact are the lag time between municipal growth and establishment of corrective municipal services, the proportion of the population increase which settles outside municipalities and along stream channels, and the tenacity with which environmental laws and regulations are enforced.

UNAVOIDABLE IMPACTS

Erosion and consequently sedimentation within mine areas would be greatly increased. The potential sedimentation rate by 1990 is estimated at 340 acre-feet per year for the region, whereas the rate in 1978 is 160 acre-feet per year. Leachate from spoil piles and replaced overburden would reduce surface water quality (see Table R4-5). Only a small portion of these impacts would be felt beyond mine areas, unless very heavy storms (100-year floods) cause breaching of the catchments and settling ponds.

There would be unavoidable localized increases in sedimentation and loss of aquatic habitat resulting from the proposed mining and associated activities. Disruption of the shallow groundwater system would destroy some point-watering sources and lush forage (along streams) during mining. The loss of watering sources would discourage stock and wildlife grazing in the affected areas. Loss of aquatic habitat and point-watering sources is expected on 330 acres of pond (including wells, playas, and springs) and 49 miles of stream by 1990. Losses by 1978 amount to 110 acres of pond and 16 miles of stream.

The area of the region where the ambient total suspended particulate (TSP) concentrations would be most affected by coal mining is a strip approximately 22 miles long and 2½ miles wide in southeast Campbell County. From 1980 to 1990, annual TSP concentrations are predicted to rise from 31 $\mu g/m^3$ to 40 $\mu g/m^3$, well below the Wyoming standard of 60 $\mu g/m^3$. While some of the coal mines are operating, the annual and 24-hour Wyoming TSP standards may be exceeded at the mine boundaries.

A slight increase of TSP concentration is expected to be caused by population growth in Gillette and emissions from Rawhide and Eagle Butte mines between 1980 and 1990. For most of this area, the TSP concentrations are expected to remain below the Wyoming ambient air quality standards. But, it is possible that the Wyoming 24-hour standard of 150 $\mu g/m^3$ may be exceeded in downtown Gillette. However, the national primary standard of 260 $\mu g/m^3$ would probably not be reached. The annual TSP concentrations around Moorcroft are predicted to increase 5 $\mu g/m^3$ between 1980 and 1990. The resultant TSP concentrations in 1990 of 30 $\mu g/m^3$ would be one-half of the Wyoming standard.

The average annual horizontal visibility away from mines and towns in the region is expected to remain near the regional baseline of 54 miles. In Gillette, the annual visibility is expected to decrease from 28 miles in 1980 to 22 miles in 1990.

The future air quality is compared to existing air quality using 1980 as the base year because of lack of air quality and emissions data for 1978.

Regionally, by 1990, all soil productivity would be lost an average of 8 to 10 years on 22,794 acres due to coal mining disturbance, or on a total of 50,603 acres for all regional development activities. These acreages represent .5% and 1% of the regional acreage respectively. Soil productivity on a total of 2,200 acres would be lost permanently due to housing developments. The disturbance of topsoil would lower to some degree the natural soil productivity by compaction, mixing natural soils, and through soil erosion.

Soil productivity on reclaimed areas (18,966 acres by 1990) would vary depending on soils types and reclamation practices on each project. Productivities may be reduced due to alteration of topsoil thickness, quality, salinity, alkalinity, acidity, or clay content. If these factors retard reclamation, erosion may increase. There would also be a reduction in productivity of stockpiled topsoil due to loss of seeds, roots, microorganisms, organic matter, and nutrients.

If a 25-, 50-, or 100-year flood occurred when mined areas were in the process of being reclaimed, an accelerated rate of erosion would occur, resulting in large amounts of soil loss and lengthening the time required for revegetation.

Wind and water erosion or contamination by spillage of toxic materials (such as oil or gasoline) would cause the loss of 5% to 10% of available topsoil material.

After disturbance and reclamation, vegetative species diversity would be lost. Vegetation on reclaimed land (18,966 acres by 1990) is expected to be dominated by grasses. Lack of diversity reduces stability of the vegetative community and the varity of wildlife it supports.

An indeterminate amount of vegetation would be impacted by dust fallout from development activity.

Since man-caused fire prevention measures are not 100% effective, an unavoidable loss of vegetation would occur due to accidental wildfire. Loss of vegetation due to fire (both man-caused and lightning-caused) in 1976 amounted to 3,500 acres; this total is likely to increase by 50% by 1990.

An estimated 3,118 animal unit months (AUMs—based on domestic livestock use where one cow equals one animal unit month) would be lost annually due to total regional development activities by 1990. A cumulative permanent loss of 6,600 AUMs would be sustained by this time period on 2,200 acres due to increased population needs (new house construction.) Additionally, 1,811 acres of cropland would be lost by 1990 from all development activities.

Expansion of residential areas and mine development would decrease the land base available for recreation, decrease wildlife habitat (and hence hunting opportunity), and interfere with sightseers' enjoyment of the natural landscape. Acreage disturbed and unreclaimed by 1990 would total 33,837, or about twice that disturbed and unreclaimed in 1978.

Present recreation facilities would have to meet the demands of increased population. Increased maintenance and repair costs would result. Resource damage may occur.

Conflicts between private landowners and recreationists would increase, probably resulting in further restriction of public access to and across private land.

The quality of the traditional "primitive"recreation experience would decline in the region due to increased population.

Increased human population would result in unquantifiable increased wildlife losses to harrassment, poaching, road kills, and domestic pets.

UNAVOIDABLE IMPACTS

Wildlife habitat would be temporarily lost on 22,794 acres (.5% of the region) of mine disturbance, or on a total of 50,603 acres (1% of the region) due to total regional development activities. Approximately 2,200 acres would be indirectly and permanently affected by 1990 due to residential and other urban structures.

The estimated numbers of wildlife lost by 1990 as a direct result of the total regional development are: 269,295 nongame birds (1% of estimated regional total), 10,767 doves (unknown percentage of regional total), 297 raptors (unknown percentage of regional total), 200,651 nongame mammals (1% of estimated regional total), 1,702 antelope (3.5% of estimated regional total), 245 deer (.8% of estimated regional total), and an unknown number of reptiles and amphibians.

Regionally, by 1990, some degree of loss or change in wildlife carrying capacity on 22,794 acres (.5% of the region) from coal mining, or on a total of 50,603 acres (1% of the region) from all development activity would occur. Carrying capacity would be lost permanently on 2,200 acres due to permanent construction.

Expanded urban areas, service facilities, and new transportation and utility networks to serve the increased population and industrialization would be permanent intrusions in the characteristic landscape.

All mine pits, stripped areas, industrial structures, machinery, buildings, and support structures (power lines, railroad spurs, and access roads) would be visual intrusions in the characteristic landscape until abandonment and revegetation is complete.

Mine activities would result in the unavoidable mining and consumption of almost 2 billion tons of coal and an undetermined amount of uranium, oil, gas, sand, gravel, and scoria by 1990. In addition, 5% to 10% of the coal would be lost because present mining methods and economics do not permit its complete recovery from overburden or partings. Coal mined from the region by 1978 totals between 1 million and 2 million tons.

All cultural resources within the region would be affected by increased vandalism and pothunting as the population increases. Surface indications of important buried sites might be lost. Significant information might be lost to the records of the region's prehistory.

Natural topography on 22,794 acres (.5% of the region) would be altered by coal mine pits and cuts and fills, and then reclaimed to unnaturally smooth contours. Replaced overburden would be unstable, tending to settle or shift over time. Even though general topography of the area can be restored, cliffs and abrupt breaks, presently a part of the topographic scene, cannot be restored. Additional topography on approximately 30,000 acres (.6% of the region) would be altered by coal conversion facilities, rail and power systems, other mineral development, and population growth.

Mining would expose the geologic record and may provide an opportunity to study this record.

The Buckskin Mine (site-specific action) is included as a part of the cumulative regional development impacts discussed above and represents 4.6% of the 22,794 coal mine acres analyzed.

CHAPTER 6

RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

The region has an established coal industry (fifteen mines are already operating or pending approval), and is facing continued development of other minerals such as oil, gas, and uranium. Projected coal development (including the site-specific project under consideration) in response to national energy needs would increase production to 173.3 million tons annually from fifteen mines by 1990. Production could level off or continue to increase beyond the 1990 projection, depending on market demands.

By 1990, about 2 billion tons of coal would be mined, or 9.2% of the estimated strippable reserves of the region. This coal would be consumed in the production of electricity or synthetic natural gas. About 150 million tons of coal would be lost by 1990, because current mining technology does not permit its economic separation from overburden and partings.

The 1978 population of Campbell and Converse counties is estimated at 25,500. By 1990, this figure would reach 47,000.

In the short term, the increased employment due to coal mining would create labor shortages in the nonmine sectors of the economy. In the long term, as more people move into the region, a labor force of sufficient size to meet the needs of all employers would be available. In addition, this increased employment would tend to hold the unemployment rate at its current low level.

Increased wage earnings and higher per capita income would in turn increase retail and wholesale trade over the life of each mine. This would be a short-term gain, while the loss of buying power of people on fixed incomes would be long term.

In the short term, housing prices would continue to rise and crowded conditions would be exacerbated. However, over the long term, the housing stock would eventually increase and match the demand.

Crowding of classrooms and increased student/teacher ratios would occur in the short term. In the long term, new facilities would be built, more teachers would be hired, and the tax base would increase to pay for these needs.

Health care in this region may never be considered up to standard, but over the long term the population/ health care specialist ratio would at least remain at the current level.

Although there would be a short-term overtaxing of some local services (water, sewer, police and fire protection, solid waste disposal, transportation), this situation would be corrected as new sewer and water systems are built, more police and fire personnel are hired, new solid waste disposal sites are developed, and highways and airports are improved.

Since mined areas can be reclaimed and restored to other uses, mining represents a short-term commitment of land use. Land occupied by expanded urban areas or new transportation facilities would be permanently committed to those developments.

Short-term disturbance of the soil resource would disrupt the productivity levels, destroy existing soil profiles, and increase soil erosional losses on 50,603 acres (1% of the region) by 1990. Soil productivity levels would be restored in the long term to varying degrees, and in some cases could equal 100% of the premining levels with successful reclamation.

Regional development would result in short-term losses of vegetation on 50,603 acres (1% of the region) by 1990. Vegetative productivity would be regained within 10 years after reclamation begins. The diversity typical of native vegetation would take 30 or more years to redevelop on reclaimed areas (University of Wyoming, Black Thunder Project Research Team 1976).

The use of 2,200 acres for housing and support services would be a long-term conversion of land use. Productivity in relation to soils, vegetation, livestock grazing, and wildlife habitat would be lost, but productivity as measured in benefits to people would be enhanced.

A total of 50,603 acres of wildlife habitat (1% of the region) would be lost for the short term by 1990, resulting in the direct loss of 1,702 pronghorn antelope, 245 deer, 10,767 doves, 297 raptors, 200,651 nongame mammals, and 269,295 nongame birds. Unquantifiable losses of reptiles and amphibians would also occur over the short term. Once reclamation is completed, repopulation, at least by small mammals and birds, is expected to be rapid.

The loss of an average of 3,118 animal unit months (AUMs) of grazing annually, the effects of dispersed recreational activities on livestock management, and the effects of haul road dust and fugitive coal dust on vegetation would be short-term losses.

The 26,210 acre-feet per year of extra water used by 1990 for municipalities and mines would not be available for other uses, but some would become available again as mining and milling projects are completed.

SHORT TERM VS. LONG TERM

Regional mineral development would temporarily consume a small part of the prevention of significant deterioration of air quality (PSD) increments. However, violations of Wyoming air quality standards are not expected except at or within mine boundaries.

Increased traffic and urbanization due to population growth would cause a long-term rise in pollutant concentrations in and near towns.

Disturbance of cultural resource sites, even with salvage, would represent a long-term commitment.

The Buckskin Mine is included in the above discussion of cumulative regional development.

CHAPTER 7

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES CAUSED BY CUMULATIVE REGIONAL DEVELOPMENT

In order to place these commitments in proper perspective, the reader is referred to Chapter 5 where a summary of these cumulative regional impacts (through 1990) may be found.

Approximately 2 billion tons of coal would be extracted and consumed as a result of regional coal mining operations through 1990, with an additional 100 to 200 million tons left as unrecoverable by present mining methods.

A large quantity of sand, gravel, and scoria estimated to be over 2 million cubic yards, would be committed to construction of mine facilities, and roads and houses to accommodate the increased population.

Energy, in the form of petroleum products and electricity, would be consumed in order to extract, convert, or ship the coal, for other development activities, and by the increased population.

The traditional life-style of towns and counties in the region would undergo additional integration with newcomers' life-styles. By 1990, newcomers' life-styles would likely predominate.

Loss of human life due to rail, highway, or mine accidents would be irreversible and irretrievable. The estimated potential fatality rate for coal strip mining is 1 per 14.3 million tons of coal produced, or 12 lives per year for the 173 million tons of coal mined annually by 1990.

Water consumed regionwide by total regional development (about 70,500 acre-feet annually) would be unavailable for other uses.

Destruction of the physical structure of the premining aquifers would be irreversible. Water in aquifers which develop after reclamation would be of poorer quality than in the premining aquifers due to high levels of dissolved solids and ions. The water may be unsuitable for drinking water or agricultural uses.

Some premining point-watering sources at 330 acres of pond or wells and along 49 miles of creek would be destroyed; the resulting loss in water source density and dispersion could cause an unquantifiable reduction in wildlife habitat and grazing range.

Existing soil associations, vegetative forage production of 4,752 animal unit months (AUMs) by 1990, total wildlife habitat and carrying capacity, and recreation land base would be permanently lost on 2,200 acres due to expansion of urban areas.

The aquatic habitat presently existing on the mine sites (330 acres of pond or wells and 49 miles of stream) would never be replaced, but a different community would naturally reestablish itself.

The quality of the "primitive"recreation experience would decline, and damage occurring to natural values throughout the region because of overuse or inadequate recreation management could be irreversible.

Wildlife presently occupying mine sites would be displaced and lost, as would subsequent generations of offspring. Estimated numbers affected directly would be 269,295 nongame birds, 10,767 doves, 297 raptors, 200,651 nongame mammals, 1,702 antelope, 245 deer, and unknown numbers of reptiles and amphibians.

An unknown amount of wildlife would be indirectly lost as a result of collisions with vehicles, poaching, and predation by pets.

Houses, service facilities, utilities, and roads built to accommodate the increased population would irreversibly commit visual resource Class II, III, and IV areas to Class V.

Land surfaces consisting of cliffs and abrupt breaks could not be restored to their original conformation after disturbance.

Cultural resources in areas of surface disturbance would be committed to either destruction or salvage; in either case, additional information would not be available to future researchers. However, present researchers would have the benefit of information gained from material exposed through mining operations.

The removal by amateurs of collectible minerals, fossils, or cultural resources would be an irreversible loss.

The Buckskin Mine is included in the cumulative regional development discussed in this chapter.

CHAPTER 8

ALTERNATIVES

INTRODUCTION

This regional environmental statement (ES) evaluates the cumulative impacts of coal development in the Eastern Powder River Basin. The production level evaluated as the probable level is dependent in part on the federal approval of the Buckskin mining and reclamation plan (M&RP) on an existing federal lease. However, the Secretary of the Interior is not proposing a particular production level for coal in the Eastern Powder River Basin. Instead, he is considering actions within his authority that will allow federal coal to be available where needed and under environmentally acceptable conditions.

In this ES, decisions regarding M&RPs and coal-related actions are assessed on a regional basis. Accompanying and future related site-specific statements will evaluate alternatives specific to the individual coal development proposals. Thus, alternatives for the M&RPs and coal-related actions are evaluated on an aggregate basis in this statement, providing a means of responding to regional environmental problems or social and economic concerns.

The Secretary's action in regard to the M&RP under consideration in this ES (site-specific analysis) may be approval as proposed, rejection on various environmental or other grounds, approval in part, or approval subject to such additional requirements or modifications as he may impose under existing laws and regulations. He may also defer decision pending submittal of additional data, completion of required studies, or for other specific reasons. If there are serious environmental concerns as to the coal development, the Secretary may exercise his exchange authority as to the federal coal rights or he may seek Congressional action cancelling the federal leases involved.

Review of the M&RP specifically assessed in this statement indicates that the following administrative alternatives are appropriate for consideration: no action, approval (evaluated as proposed action), approval subject to specific modifications or requirements, and deferral of the decision on significant environmental grounds.

Alternative sites for surface facilities, mining technology and methods, coal transport methods, and rates of production on individual operations were considered where appropriate, but no such modifications have been proposed or identified which would significantly reduce the adverse impacts of coal production from the region. Any new alternatives surfaced by the review process will be carefully considered.

Development of alternative sources of energy, energy conservation, federal development of the coal, and emphasis on coal development in other regions of the nation are more appropriate for consideration on a national rather than a regional basis. These evaluations were made in the previous coal programmatic statement and will be updated and revised as necessary in the new coal programmatic statement now underway.

Regional Alternatives

Alternatives available in regard to coal development in this region fall into several broad categories:

No Federal Action. This means nonapproval or rejection of the pending M&RPs on federal leases along with any related permits or rights-of-way. It would not affect continued development of nonfederal coal or federal coal being produced on leases for which mine plans have already been approved. (However, federal coal could be made available under approved short-term competitive standards to maintain ongoing coal development.) Analysis of impacts of the no federal action alternative is discussed as the low-level scenario later in this chapter.

Defer Further Federal Coal Development Pending Demonstration of Successful Reclamation. Under this alternative, further federal coal development in the Eastern Powder River Basin would be deferred until it could be demonstrated that areas disturbed by mining activities can be reclaimed to the standards of the Surface Mining Control and Reclamation Act (SMCRA).

Past reclamation attempts in the region have had some success (see Chapter 4, Vegetation). To date, the Wyoming Department of Environmental Quality has not released any area as being satisfactorily reclaimed.

It is estimated that an initial judgment on reclamation success could be made in 3 to 5 years after reclamation begins. However, reclamation efforts would be monitored by the authorized agencies, and the final acceptance would be based on SMCRA standards.

Delaying federal coal development in the region would postpone the impacts discussed in Chapter 4. If revegetation could not be accomplished, the following impacts would occur.

1. The mining companies would be forced to shut down their operations.

2. Shut-down of the mines would cause economic loss to the mining companies, loss of employment for most of the employees, and partial loss of investment in equipment and material needed to open and operate the mines.

3. Areas disturbed during the period of mining would be unreclaimed, or at best only partially reclaimed.

4. The consumers of the coal from the mines would need to obtain coal from other sources.

5. The reduction in labor force and earnings would cause socioeconomic impacts in the region.

Approval Subject to Specific Modifications or Requirements. On a regional basis, no generally applicable modifications or requirements which will significantly mitigate predicted impacts have been identified. However, the site-specific portion of the ES considers specific modification or requirements to mitigate impacts due to implementation of the Buckskin M&RP. Any modification or requirement suggested in the public review will be carefully considered.

Fish and Wildlife Mitigation Alternatives. The recommendations which follow would reduce or eliminate the major impacts to existing fish and wildlife resources described in Chapter 4.

(1) All mining areas should be reclaimed to wildlife habitat as soon as feasible. Reclamation would be in conformance to the postmining land use established by the State of Wyoming (Department of Environmental Quality) and/or the Bureau of Land Management or the U.S. Forest Service. Vegetative planting and reclamation should be accomplished in consultation with the Wyoming Game and Fish Department and the U.S. Fish and Wildlife Service. The goal of reclamation should be to achieve the highest possible wildlife carrying capacity at the earliest possible date, regardless of cost. All possible tools to achieve this goal should be implemented as needed.

(2) Approximately 53,000 acres of land lying in a suitable area where public domain (or private land under cooperative agreement) is available should be set aside amd managed intensively for fish and wildlife resources. Selection of such an area should be accomplished in consultation with the Wyoming Game and Fish Department and the U.S. Fish and Wildlife Service. The area set aside should be managed to increase its wildlife carrying capacity by at least 50%. Management tools such as water development, fertilization, vegetative manipulation, spraying, transplanting, seeding, protection of wildlife cover, and management of livestock grazing to enhance wildlife habitat should be implemented as necessary. The habitat should be controlled by the surface-management agency and wildlife by the Wyoming Game and Fish Department.

(3) It should be provided that a mine permit will not be granted on land critical to the ecological requirements of the bald or golden eagle. A team of qualified biologists from the U.S. Fish and Wildlife Service, the Wyoming Game and Fish Department, and the Bureau of Land Management or the U.S. Forest Service will judge and recommend the areas to be excluded from mining. A mine permit could be granted if regulations are adopted to provide for buffer zones and alternate prey bases and nesting sites, and if that acreage critical to the eagle is not affected.

Production Levels. A "best estimate"as to the probable production level was used as a basis for evaluation of cumulative impacts from coal development within the region. Actual production levels attained will depend partly on demand as well as on the availability of coal. Factors influencing production levels in the region include access and economics in relation to other coal sources, transportation, local and state as well as federal approvals, and pollution control requirements and technology. As previously indicated, availability of the coal resource to meet market demands or production could well occur at a significantly lower or higher level than the identified probable level. These alternate production scenarios are evaluated in the remainder of this chapter for impact.

NO-ACTION ALTERNATIVE (LOW-LEVEL SCENARIO)

Since the no-action alternative and the low-level scenario use the same coal production levels and data, they are presented together as the no-action alternative (low-level scenario).

The no-action alternative presents an assessment of a level of coal development which is lower (low-level scenario) than the most probable level described and analyzed in the first seven chapters of this ES. No action is disapproval of the federal proposed action (Buckskin Mine) presently before the Department of the Interior. The no-action alternative also assumes future disapproval of all Department of the Interior authorizations for new coal mining proposals through the year 1990.

This would mean no further approval of mining and reclamation plans, no consideration of preference right lease applications, and no development of presently unleased federal coal. However, for coal being produced from existing mines, land use authorizations necessary for facilities to transport or convert coal to other forms of energy could be considered.

The no-action alternative (low-level scenario) presents a cumulative analysis of impacts of all coal activities not dependent on new coal mining in the region, plus other regional activity. Cumulative impacts of the fourteen mines which are presently operating or pending approval (under study in separate site-specific ESs) are included. (Cumulative impacts of this level of mining were originally analyzed in the final environmental statement on the Eastern Powder River Coal Basin of Wyoming (FES 74-55).) Annual coal production from these fourteen mines would increase from 49.5 million tons in 1978 to 107.0 million tons in 1980, 164.6 million tons in 1985, and 169.3 million tons in 1990. Increasing production is attributed to mines which have only recently been approved and are still being developed to full planned production. Further information on these mines is presented in Table R8-1. Other coal-related activities include a new power plant, a coal gasification plant, and a new major rail line. Other major regional development includes oil and gas, uranium, transmission line construction, and municipal development as discussed in Chapter 1.

Tables R8-2, R8-3, R8-4, and R8-5 define, derive, and summarize the acreage and water requirements for the no-action (low-level scenario) alternative. Assumptions and analysis guidelines used in developing the analysis of the low-level scenario are the same as those in the first chapter (see Assumptions and Analysis Guidelines, Chapter 1).

Impact Analysis

The impacts of the no-action alternative (low-level scenario) are analyzed at two levels: (1) the impacts of development and continuation of the fourteen existing coal mines, and (2) the cumulative impacts of all development in the region under the low-level scenario. The analysis of the no-action alternative (low-level scenario) focuses on impacts which differ significantly from those discussed in Chapter 4 and, therefore, the reader is directed to that chapter for additional detail on the general character of impacts.

Air Quality

Emissions and Modeling Procedures. The emission sources examined for the low-level scenario are surface coal mines, uranium mines, two coal-fired power plants, a coal gasification plant, towns, and transportation. The locations of the low level developments are shown on Map 1, Appendix A. The particulate emissions from the coal and uranium mines are listed in Table R8-6. The estimated particulate, sulfur oxide (SO_x) and nitrogen oxide (NO_x) emissions from the Dave Johnston and Wyodak power plants, the Panhandle Eastern gasification plant, and the towns of Gillette, Moorcroft, Douglas, Glenrock, and Casper are shown in Table R8-7. The emissions from the mines and towns were calculated using the assumptions and procedures summarized in Chapter 4, Air Quality. The emission rates for the two power plants and the gasification plant were taken from the sources listed in Chapter 4.

The increase in vehicular emissions was not included in the dispersion modeling because it is anticipated that their impact on regional air quality would not be significant. In addition, emissions were not quantified for oil and gas development in the region. No specific information concerning possible locations of new oil and gas development was available.

Coal Development in the Low-Level Scenario. The primary effect of surface mining of coal would be to increase emissions of pollutants at the mines. Since most of the fugitive dust generated by mining operations consists of relatively large-diameter particles, most particle deposition occurs within a few miles of each mine.
Concentrations which follow refer to the contributions from the coal development in the low-level scenario. These concentrations do not include the baseline levels nor contributions from other activities.

The major TSP impact from the coal mines would be in southeast Campbell County, where five mines lie in a strip approximately 22 miles long and 2½ miles wide. From 1980 to 1990, annual TSP concentrations in this area would increase 5 micrograms per cubic meter ($\mu g/m^3$). The maximum 24-hour concentrations would increase 17 $\mu g/m^3$. TSP increases above baseline would drop to near zero at distances greater than 10 miles from the mine boundaries. By 1990, interactions between the emissions from adjacent mines should.cause annual TSP concentrations in the area between the mines to rise 10 $\mu g/m^3$. Maximum 24-hour concentrations in this section of the region in 1990 are predicted to be in the 21 to 34 $\mu g/m^3$ range. The annual TSP concentration from the existing mines alone would not exceed the state standard of 60 $\mu g/m^3$ except possibly within the mine boundaries.

Any potential violations discussed above would not occur with application of the new prevention of significant air quality deterioration (PSD) regulations (43 CFR 118).

Coal Development and Other Major Activities of the Low-Level Scenario. The emission sources included in this category are the uranium mines, power plants, oil and gas development, and municipal facilities as well as the previously mentioned coal mines.

Concentrations mentioned in this section refer to the total air quality (including rural baseline) due to the entire low-level scenario.

Predicted annual TSP concentrations are shown on Figures R8-1, R8-2, and R8-3. Significant TSP concentrations would occur in southeast Campbell County which encompasses five coal mines. In this area, annual TSP concentration would be 30 $\mu g/m^3$ (6 $\mu g/m^3$ above the rural background concentration). Concentrations would reach 35 $\mu g/m^3$ in the area between mines situated close to one another. The increase in TSP concentration would drop to 1 $\mu g/m^3$ beyond 10 miles from any of the mines.

Two uranium mines would significantly impact air quality. These mines are close enough for their emissions to interact with one another and also interact with emissions from the Dave Johnston Power Plant and the Panhandle Eastern Gasification Plant. In a 2-mile wide strip between the Highland and Morton Ranch mines (north of Glenrock) the TSP levels would reach 30 $\mu g/m^3$. The maximum 24-hour concentrations around these two mines and those discussed above is estimated to be 103 $\mu g/m^3$. The annual and 24-hour Wyoming air quality standards of 60 $\mu g/m^3$ and 150 $\mu g/m^3$ might be exceeded at the boundary of some of the existing mines.

Again, with the new interpretation of fugitive dust in 43 CFR 118, it is unlikely that the above violation would occur.

Emissions due to Gillette's population growth and interactions with emissions from the Rawhide and Eagle Butte mines (north of Gillette) would be expected to produce annual TSP concentrations of 30 $\mu g/m^3$. The impact would be confined to the area containing Gillette and the two mines. Concentrations nearer to Gillette are expected to reach 35 $\mu g/m^3$ in 1980 and 1985 and 40 $\mu g/m^3$ in 1990. The maximum 24-hour TSP concentrations would occur in Gillette. A 24-hour maximum concentration of 129 $\mu g/m^3$ is predicted in 1985 and 136 $\mu g/m^3$ in 1990. It is possible that Wyoming's 24-hour TSP stand-

TABLE R8-1

LOW LEVEL OF COAL DEVELOPMENT (EXISTING COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Projects	Annual Coal Production (MM Tons/Year)				Time Frame		
	1978	1980	1985	1990	Construction Start Up	Full Mine Operation	Mine Life (Years)
Existing Mines							
Operating Mines							
Wyodak	0.9	2.5	2.5	2.5	1922	1979	98
Dave Johnston	3.2	3.2	3.2	3.2	1958	1970	43
Belle Ayr	18.0	16.0	19.0	19.0	1973	1985	23
Cordero	9.2	20.0	24.0	24.0	1976	1981	25
Rawhide	3.0	9.0	12.0	12.0	1977	1982	40
Black Thunder	5.8	13.7	20.0	20.0	1978	1983	40
Jacobs Ranch	2.6	10.7	15.7	15.4	1975	1984	23
Kerr-McGee #16	1.0	4.2	4.2	4.2	1978	1979	14
Eagle Butte	5.8	13.2	20.0	20.0	1978	1984	39
Environmental Statement In Progress							
Caballo	0	3.0	7.0	12.0	1977	1987	39
Coal Creek	0	4.0	10.0	10.0	1978	1983	36
East Gillette	0	4.0	11.0	11.0	1979	1982	35
Rochelle[1]	0	0	11.0	11.0	1982	1984	29
Pronghorn	0	3.5	5.0	5.0	1979	1981	22
TOTAL	49.5	107.0	164.6	169.3			

TABLE R8-1
(cont'd)
LOW LEVEL OF COAL DEVELOPMENT (EXISTING COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Projects	Total Permit Acres[2]	Federal Coal Acres	Total Surface to be Disturbed By 1990[3]	Average Acres Disturbed Per Year[4]	Acres Reclaimed By 1990
Existing Mines					
Operating Mines					
Wyodak	3,240	1,880	363	50	243
Dave Johnston	13,990	9,660	2,760	80	1,565
Belle Ayr	5,960	2,360	1,947	165	1,643
Cordero	8,390	6,560	3,174	285	1,820
Rawhide	5,720	5,457	755	80	410
Black Thunder	8,280	5,884	1,285	175	975
Jacobs Ranch	4,960	4,352	1,760	170	1,345
Kerr-McGee #16	960	0	559	57	572
Eagle Butte	4,470	3,520	1,208	85	611
Environmental Statement In Progress					
Caballo	7,850	5,330	1,220	195	805
Coal Creek	9,605	5,800	1,270	185	808
East Gillette	3,440	3,440	1,100	77	990
Rochelle	5,000	10,820	873	160	555
Pronghorn	2,640	4,000	455	45	310
TOTAL	84,505	69,063	18,729	1,809	12,652

TABLE R8-1
(cont'd)
LOW LEVEL OF COAL DEVELOPMENT (EXISTING COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

	EMPLOYMENT[5]					
	1980		1985		1990	
Projects	Construction	Permanent	Construction	Permanent	Construction	Permanent
Existing Mines						
Operating Mines						
Wyodak	0	48	0	55	0	55
Dave Johnston	0	135	0	135	0	135
Belle Ayr	0	255	0	334	0	334
Cordero	0	166	0	277	0	277
Rawhide	0	322	0	430	0	430
Black Thunder	0	350	0	500	0	500
Jacobs Ranch	0	212	0	250	0	250
Kerr-McGee #16	0	123	0	123	0	125
Eagle Butte	0	211	0	350	0	350
Environmental Statement In Progress						
Caballo	121	195	0	430	0	430
Coal Creek	194	55	0	250	0	250
East Gillette	5	110	5	161	0	161
Rochelle	200	190	0	190	0	190
Pronghorn	0	226	0	279	0	279
TOTAL	520	2,608	5	3,764	0	3,766

TABLE R8-1
(cont'd)
LOW LEVEL OF COAL DEVELOPMENT (EXISTING COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Projects	Estimated Number of Unit Trains for the Years[6] 1980	1985	1990	Market Area
Existing Mines				
Operating Mines				
Wyodak	45[7]	45[7]	45[7]	Mine mouth (Wyodak), South Dakota
Dave Johnston	0[7]	0[7]	0[7]	Mine mouth (Dave Johnston Power Plant)
Belle Ayr	1,600	1,900	1,900	Colorado, Texas, Arkansas, Kansas, Ohio, Iowa
Cordero	2,000	2,400	2,400	Wyoming, Texas
Rawhide	900	1,200	1,200	Iowa, Indiana
Black Thunder	1,370	2,000	2,000	Texas
Jacobs Ranch	1,070	1,570	1,540	Arkansas, Louisiana
Kerr-McGee #16	420	420	420	None
Eagle Butte	1,320	2,000	2,000	Southern, midwestern, and Ohio Valley states
Environmental Statement In Progress				
Caballo	300	700	1,200	Nebraska, Michigan, Indiana
Coal Creek	400	1,000	1,000	Texas
East Gillette	400	1,100	1,100	None
Rochelle	0[7]	0[7]	0[7]	None
Pronghorn	350	500	500	Minnesota, Iowa, Wisconsin, Illinois, Gulf Coast states
TOTAL	10,175	14,835	15,305	

TABLE R8-1
(cont'd)
LOW LEVEL OF COAL DEVELOPMENT (EXISTING COAL MINING) BY 1990 IN THE EASTERN POWDER RIVER BASIN

Source: Mine information was developed from mining and reclamation plans currently on file with the Area Mining Supervisor, U.S. Geological Survey.

[1] Additional federal coal lease reserves are anticipated to be mined as a part of this operation in the future, which may extend indicated mine life.

[2] All acreage within the area of operations for the mine.

[3] Only acreage disturbed by mining operations. By 1990, 3,404 additional acres will be disturbed by mine facilities.

[4] Average annual rate for new surface disturbance by mining activity.

[5] Employment data in the mining and reclamation plans were updated where possible by personal communication with the mining companies.

[6] One unit train equals 100 cars, each car having a capacity of 100 tons of coal. Does not include return traffic. Coal exported from the region is shipped south, east, or southeast.

[7] This number does not represent full transport of the mine production by unit train. Coal consumed at mine mouth is generally transported short distances by truck or private rail.

TABLE R8-2

CUMULATIVE DEVELOPMENT FOR THE REGION
LOW LEVEL OF DEVELOPMENT

	1978	1980	1985	1990
Coal Mining				
Number of Coal Mines*	11	14	14	14
Coal Mine Support Facilities:				
Miles of Rail Spurs	41	55	55	55
Miles of Telephone Lines	34	50	50	50
Miles of Access Roads	11	19	19	19
Miles of Conveyor System	0	7	7	7
Miles of Power Lines	76	93	93	93
Coal-Related Development				
Number of Power Plants**	2	2	2	2
Number of Gasification Plants	0	0	1	1
Miles of Railroad Line				
Main Line (common-carrier)	26	113	113	113
Private	0	0	40	40
Uranium				
Cumulative Number of Uranium Mines	3	4	6	7
Cumulative Number of Uranium Mills	2	3	4	4
Oil and Gas				
Area of Activity (acres)	4,800	4,880	5,112	5,247
Other				
Miles of New 230-kv Transmission Lines	0	0	87	87
Population Increase (1,000s)	0	3	17	21

Note: 1978 base, and based on industry plans and indicated trends.
* Counts East Gillette and Kerr McGee #16 individually.
** Wyodak and Dave Johnston.
*** Under construction.
**** Centaur Management Consultants, Inc. 1978. Based on projection model for Campbell and Converse counties (University of Wyoming 1978). Population increases represent increased population over the 1978 base population (25,500).

TABLE R8-3

SUMMARY OF CUMULATIVE ACREAGES DISTURBED AND RECLAIMED BY COAL MINING ACTIVITY
LOW LEVEL OF DEVELOPMENT

	Cumulative Acreage 1978	1980	1985	1990
Surface Mine Operations	2,700	4,712	12,677	18,729
Power Lines	455	558	558	558
Rail Spurs	861	1,155	1,155	1,155
Access Roads	132	228	228	228
Conveyor Systems	0	70	70	70
Mine Structures	1,139	1,360	1,360	1,360
Relocations	36	36	36	36
Totals: Acres Disturbed	5,323	8,119	16,084	22,136
Acres Reclaimed	1,301	3,495	9,887	12,652
Difference	4,022	4,624	6,197	9,484

Note: For average acreage requirements, please refer to Table R1-4.

TABLE R8-4

CUMULATIVE ACREAGE DISTURBED AND RECLAIMED BY ALL DEVELOPMENT ACTIVITIES
LOW LEVEL OF DEVELOPMENT

	1978	1980	1985	1990
Acreage Disturbed				
Coal Mining Activity*	5,323	8,119	16,084	22,136
Power Plants	2,000	2,000	2,000	2,000
Coal Gasification	0	0	1,500	1,500
Railroad Line				
Main Line	546	2,373	2,373	2,373
Private	0	0	840	840
Uranium	4,000	5,000	9,500	13,000
Oil and Gas	4,800	4,880	5,110	5,250
Sand, Gravel, Scoria	200	200	620	1,280
230-kv Transmission Line	0	0	1,566	1,566
Population**	0	300	1,700	2,100
TOTAL	16,869	22,872	41,293	52,045
Acreage Reclaimed				
Coal Mining Activity*	1,301	3,495	9,887	12,652
Other Activities	400	1,400	3,550	6,300
TOTAL	1,701	4,895	13,437	18,952
Difference	15,168	17,988	27,856	33,093

Note: For average acreage requirements, refer to Table R1-4.
* From Table R8-3.
** Acreage required for population increase over 1978 base municipal acreage.

TABLE R8-5

INCREASED WATER USAGE FOR THE REGION
LOW LEVEL OF DEVELOPMENT

Annual Water Requirements (acre-feet)

Type of Use	1975	1978	Inc.*	1980	Inc.*	1985	Inc.*	1990	Inc.*
Coal Mines	170	1,000	830	2,120	1,950	3,320	3,150	3,420	3,250
Irrigation	10,000	10,000	0	10,000	0	10,000	0	10,000	0
Municipal**	3,990	6,650	2,660	7,980	3,990	9,880	5,890	10,260	6,270
Oil Field (water-flood)	12,000	12,000	0	12,000	0	12,000	0	12,000	0
Uranium Mines	80	240	160	320	240	480	400	560	480
Uranium Mill	500	2,000	1,500	3,500	3,000	7,500	7,000	9,500	9,000
Power Plants***	7,500	7,630	130	7,630	130	7,630	130	7,630	130
Gasification Plant	N/A	N/A	N/A	N/A	N/A	7,000	7,000	7,000	7,000
Stock Water and Domestic	10,000	10,000	0	10,000	0	10,000	0	10,000	0
Totals	44,240	49,520	5,280	53,550	9,310	67,810	23,570	70,370	26,130
Sewage**** (Based on 70% of municipal use)	2,800	4,600	1,800	5,600	2,800	6,900	4,100	7,200	4,400

Note: Please see Table R1-7 for water use requirement factors.
* Increase over base year (1975).
** Includes need for projected population increase in region.
*** Includes Wyodak air-cooled and Dave Johnston water-cooled plants.
**** Not a part of cumulative total.

N/A = not applicable

TABLE R8-6

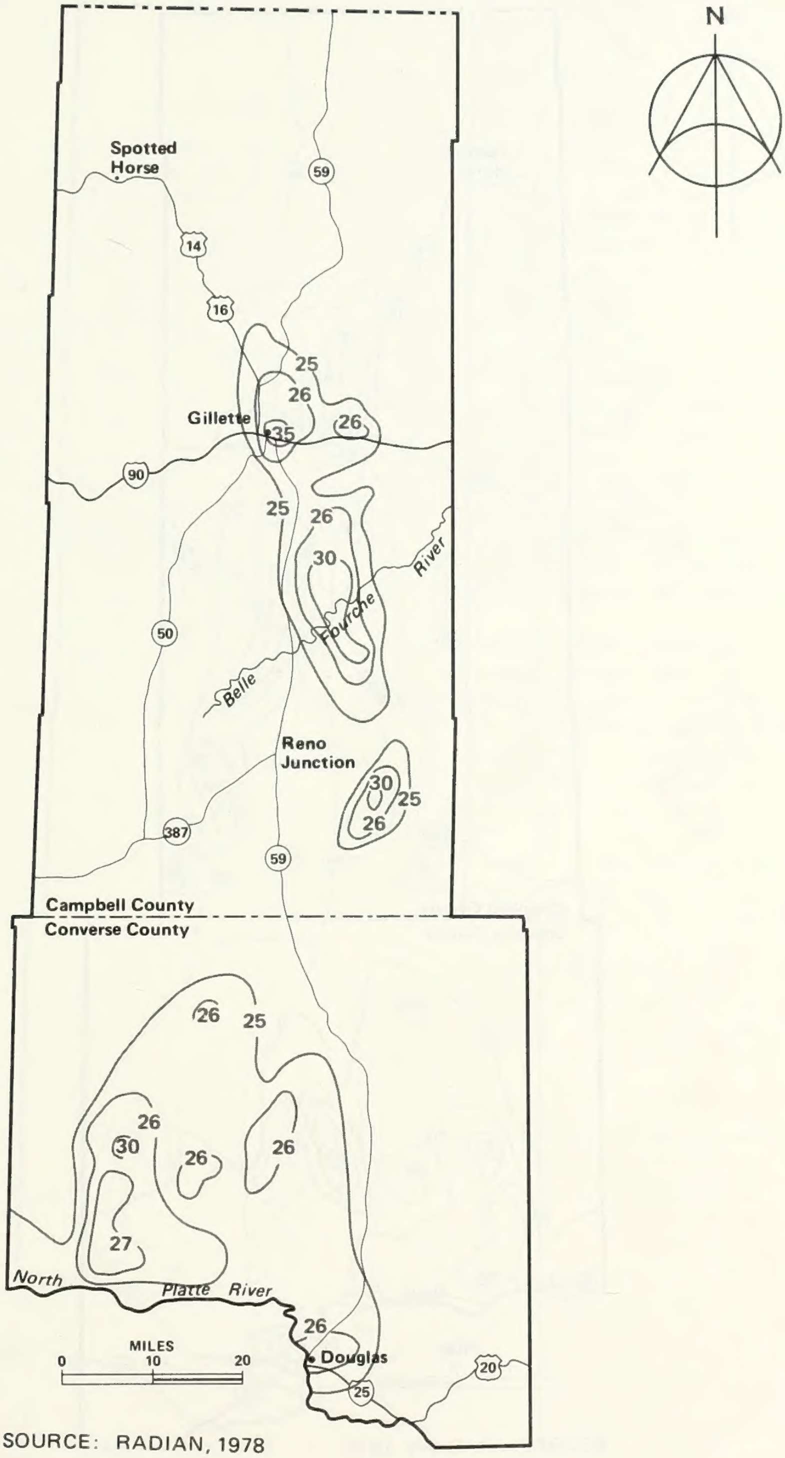
PARTICULATE EMISSIONS (TONS/YEAR) FROM MINING ACTIVITY IN THE LOW-LEVEL SCENARIO

Mine	Year 1980	1985	1990
Coal Mines			
Rawhide	1,596	2,026	2,218
Eagle Butte	2,077	3,222	3,096
East Gillette	1,670	1,531	1,492
Kerr McGee #16	765	1,200	1,240
Wyodak	406	434	682
Caballo	606	1,598	3,651
Belle Ayr	5,024	4,289	4,520
Pronghorn	801	1,628	1,769
Cordero	10,448	9,241	9,241
Coal Creek	1,481	3,432	3,432
Jacobs Ranch	2,431	2,754	3,149
Black Thunder	3,717	4,743	3,744
Dave Johnston	1,356	1,068	961
Rochelle	0	2,428	2,318
Uranium Mines			
Highland	1,763	2,655	3,425
Bear Creek	854	890	885
Morton	883	1,635	1,770
Bill Smith	854	910	910
Potential Mine	0	855	890
Potential Mine	0	0	855

TABLE R8-7

EMISSONS OF PARTICULATES, SO_x, AND NO_x FROM COAL-RELATED ACTIVITIES AND URBAN AREAS (TONS/YEAR)

Source	Pollutant	Year 1980	1985	1990
Coal-Related Activities				
Wyodak Power Plant	Particulates	1,755	1,755	1,755
	SO_x	14,100	14,100	14,100
	NO_x	11,227	11,227	11,227
Dave Johnston Power Plant	Particulates	18,542	18,542	18,542
	SO_x	19,637	19,637	19,637
	NO_x	19,053	19,053	19,053
Panhandle Eastern Coal Gasification Plant	Particulates		1,376	1,376
	SO_x		11,884	11,884
	NO_x		13,667	13,667
Towns (Low-Level Scenario)				
Gillette	Particulates	248	380	482
	SO_x	263	402	511
	NO_x	1,434	2,179	2,778
Moorcroft	Particulates	51	80	99
	SO_x	44	69	84
	NO_x	252	402	489
Glenrock	Particulates	62	102	91
	SO_x	47	73	73
	NO_x	328	500	507
Douglas	Particulates	124	274	241
	SO_x	99	219	193
	NO_x	686	1,500	1,325
Casper	Particulates	2,146	2,493	2,905
	SO_x	2,358	2,745	3,190
	NO_x	6,913	8,041	9,709



SOURCE: RADIAN, 1978

Figure R8-1
ANNUAL TSP CONCENTRATIONS (μg/m³)
FOR THE LOW LEVEL SCENARIO FOR 1980

TABLE R8-7

EMISSONS OF PARTICULATES, SO_x, AND NO_x FROM COAL-RELATED ACTIVITIES AND URBAN AREAS (TONS/YEAR)

Source	Pollutant	Year 1980	1985	1990
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	NO_x	19,053	19,053	19,053
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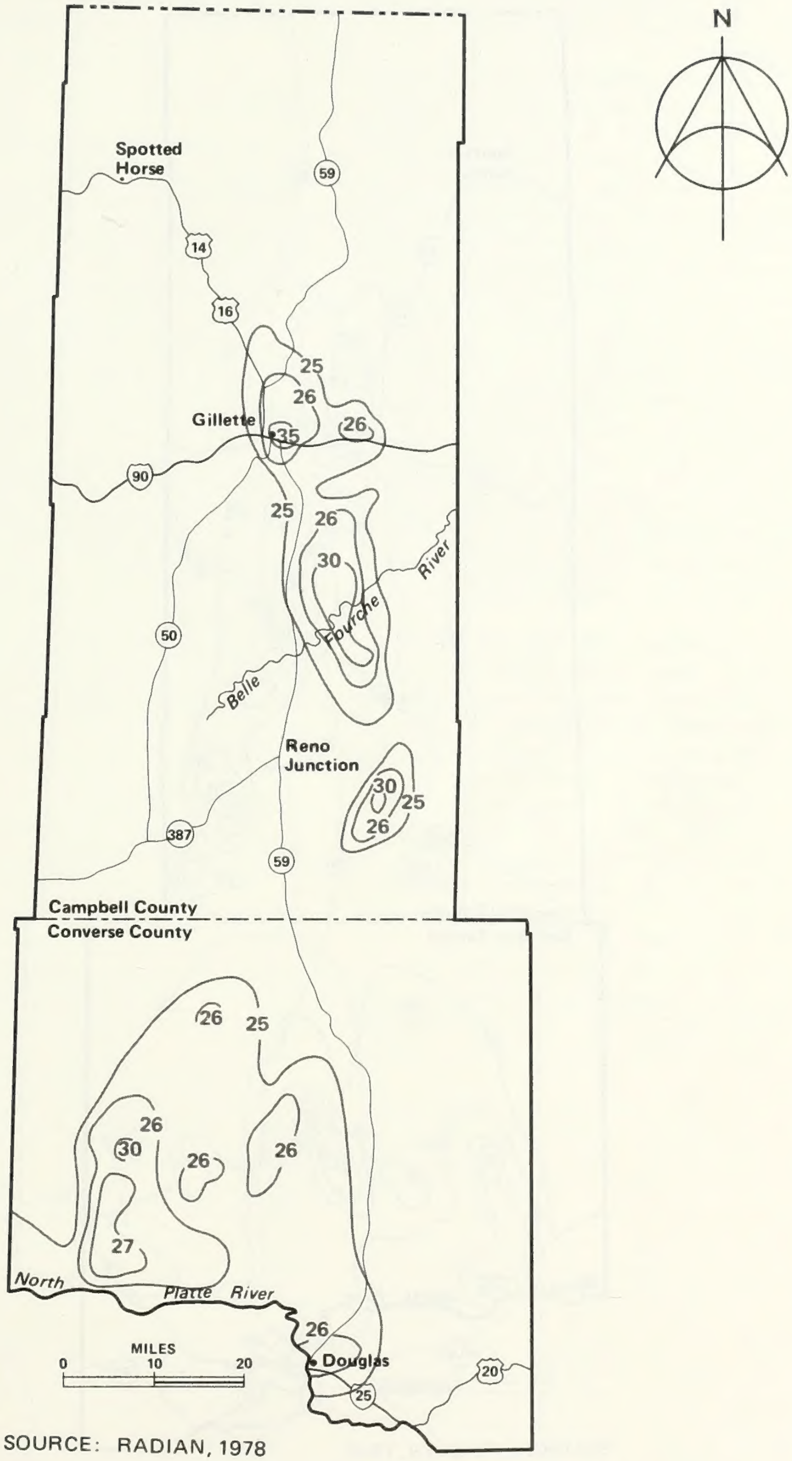
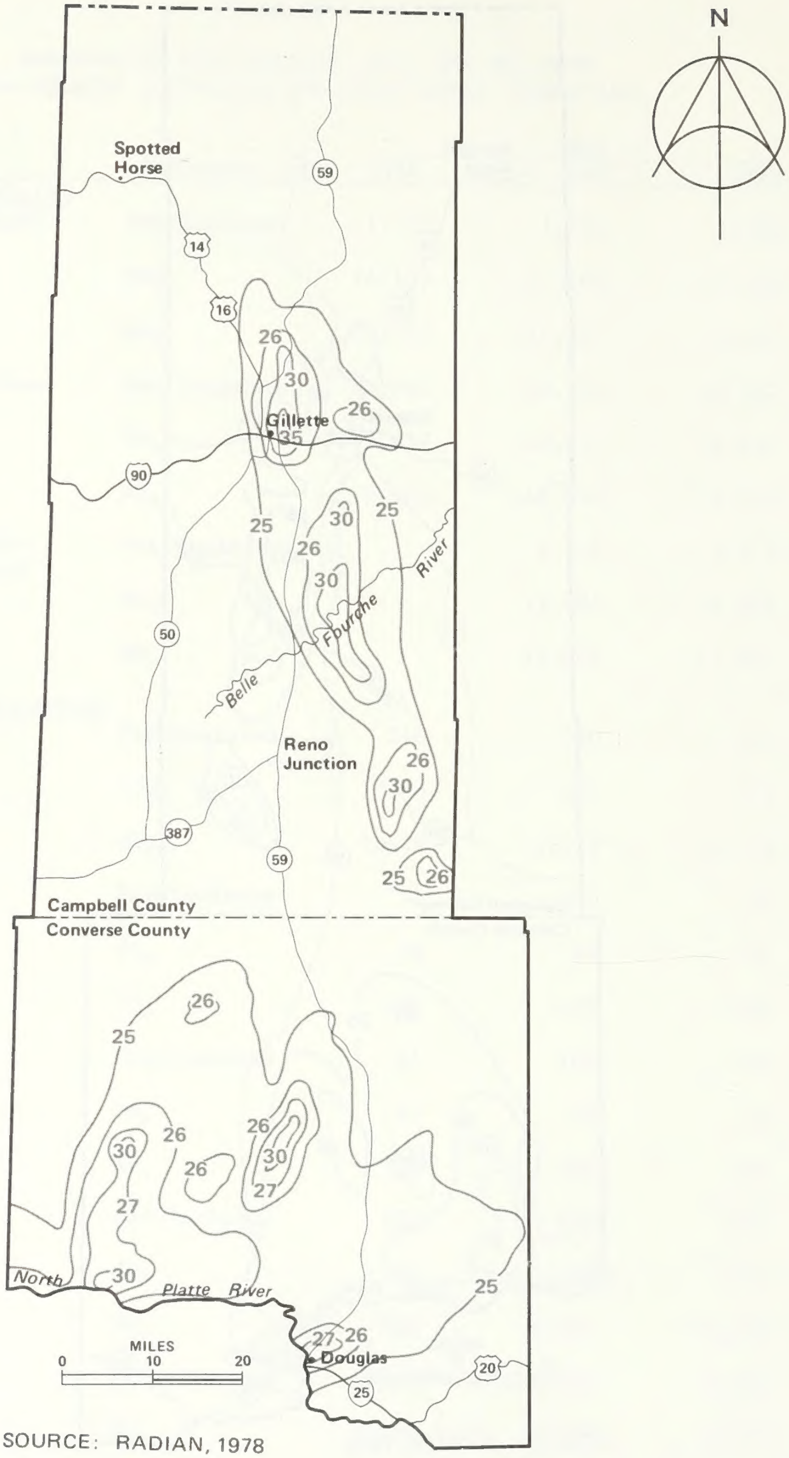


SOURCE: RADIAN, 1978

Figure R8-1
ANNUAL TSP CONCENTRATIONS (μg/m³)
FOR THE LOW LEVEL SCENARIO FOR 1980



SOURCE: RADIAN, 1978

Figure R8-2
ANNUAL TSP CONCENTRATIONS ($\mu g/m^3$)
FOR THE LOW LEVEL SCENARIO FOR 1985

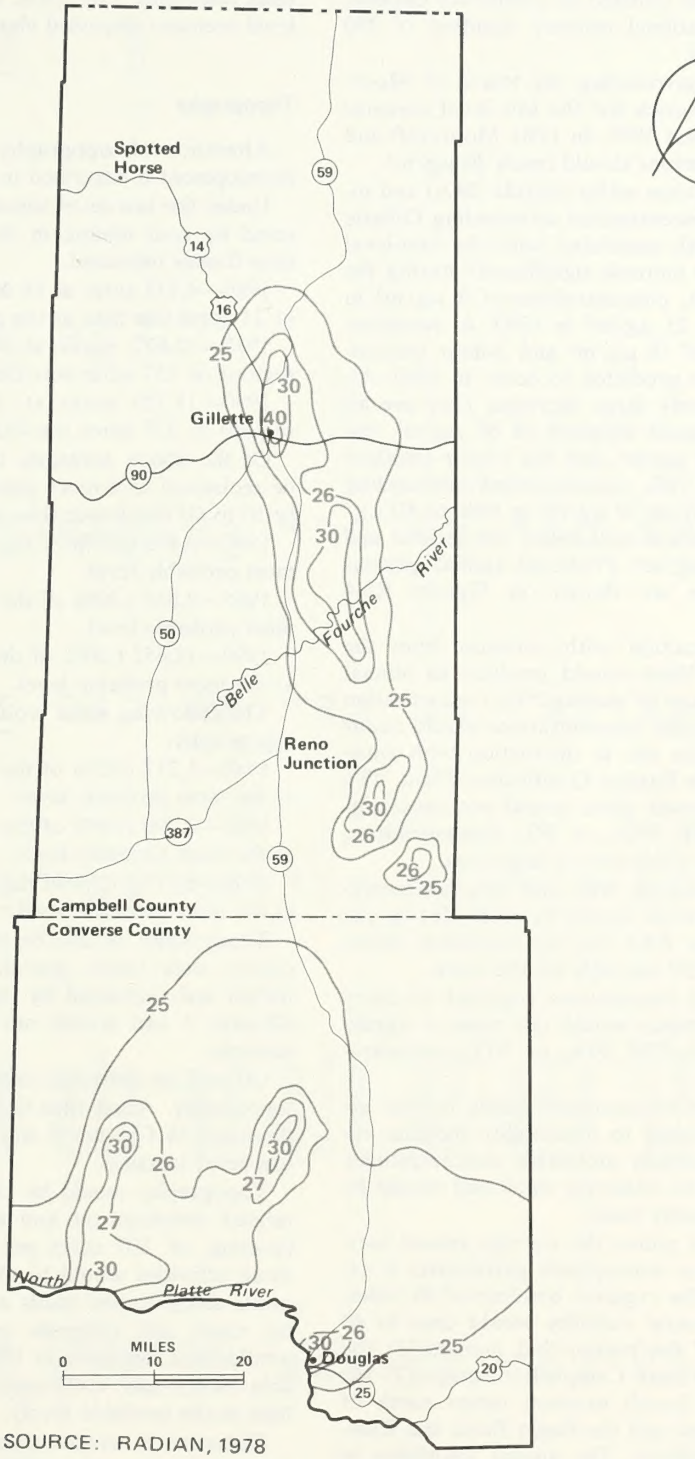


Figure R8-3

ANNUAL TSP CONCENTRATIONS (μg/m³) FOR THE LOW LEVEL SCENARIO FOR 1990

ard (150 $\mu g/m^3$) might be violated in downtown Gillette, but unlikely that the national primary standard of 260 $\mu g/m^3$ would be reached.

TSP concentrations surrounding the towns of Moorcroft, Douglas, and Glenrock for the low-level scenario would be small in 1980 and 1985. In 1990, Moorcroft and Glenrock TSP concentrations should reach 30 $\mu g/m^3$.

The annual and short-term sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations surrounding Gillette due to population growth associated with the low-level scenario are expected to increase significantly during the study years. Annual SO_2 concentrations of 8 $\mu g/m^3$ in 1980 would increase to 23 $\mu g/m^3$ in 1990. A maximum 24-hour concentration of 78 $\mu g/m^3$ and 3-hour concentration of 129 $\mu g/m^3$ are predicted to occur in 1990. Although these are relatively large increases they are all below the Wyoming annual standard of 60 $\mu g/m^3$, the 24-hour standard of 260 $\mu g/m^3$, and the 3-hour standard of 1,300 $\mu g/m^3$. Annual NO_2 concentrations surrounding Gillette would increase from 30 $\mu g/m^3$ in 1980 to 60 $\mu g/m^3$ in 1990. These levels are well below the federal and state standards of 100 $\mu g/m^3$. Predicted annual gaseous pollutant concentrations are shown on Figures R8-4 through R8-9.

Near Glenrock, interaction with emission from the Dave Johnston Power Plant would produce an annual SO_2 concentration of 8 $\mu g/m^3$ and an NO_2 concentration of 20 $\mu g/m^3$ in 1990. Similar concentrations would occur in the vicinity of Douglas due to interaction with emissions from the Panhandle Eastern Gasification Plant. The gasification plant and power plant would not cause significant increases in TSP, NO_2, or SO_2 concentrations, but their small influence is felt over a large area.

The annual and short-term NO_2 and SO_2 concentrations surrounding Moorcroft would be small during the study period. See Table R8-8 for the maximum short-term concentration of TSP and SO_2 for the town.

Emissions from diesel locomotives required to carry coal from the existing mines would not cause a significant rise in the regional TSP, SO_2, or NO_2 concentration.

The air quality impact of commuter traffic for the existing mines is not expected to measurably increase regional TSP, NO_2, or carbon monoxide concentrations. These emissions would be relatively small and would be highly variable on an hourly basis.

Away from towns and mines, the average annual horizontal visibility related to atmospheric particulates is expected to remain near the regional baseline of 54 miles. The mean annual horizontal visibility would drop to 48 miles near the areas of the region that include (1) the five coal mines in southeast Campbell County, (2) the Highland and Morton Ranch uranium mines north of Glenrock and, (3) Gillette and the Eagle Butte and Rawhide mines north of Gillette. The annual visibilities in Gillette are estimated to decrease from 40 miles in 1980 to 35 miles in 1990. The visibility near Gillette during the period of highest predicted 24-hour TSP concentrations would be approximately 17 miles in 1990.

The Chapter 8 Technical Report, on file at the Casper District Office of the Bureau of Land Management, contains additional TSP, SO_2, and NO_2 analyses of the low-level scenario discussed above.

Topography

Alteration of topography under the probable level of development is described in Chapter 4.

Under the low-level scenario, topography would be altered by coal mining in the following amounts for the time frames indicated.

1980—4,712 acres at 14 mine sites (.09% of the region) or 21 acres less than at the most probable level.

1985—12,677 acres at 14 mine sites (.30% of the region) or 257 acres less than at the most probable level.

1990—18,729 acres at 14 mine sites (.38% of the region) or 377 acres less than at the most probable level.

Of the above acreages, the following amounts would be reclaimed to a more gentle, smoother surface generally 10 to 40 feet lower than now exists.

1980—3,495 (.07% of the region) or the same as at the most probable level.

1985—9,887 (.20% of the region) or the same as at the most probable level.

1990—12,652 (.30% of the region) or 14 acres less than at the most probable level.

The following areas would remain in pit and spoil pile topography.

1980—1,217 (.02% of the region) or 21 acres less than at the most probable level.

1985—2,790 (.06% of the region) or 257 acres less than at the most probable level.

1990—6,077 (.12% of the region) or 363 acres less than at the most probable level.

Topography would be altered at uranium mines and quarry sites (sand, gravel, and scoria). Acreages disturbed and reclaimed by these activities are discussed in Chapter 4 and would not change under the low-level scenario.

Oil and gas activities cause only slight alteration of the topography. Areas thus disturbed and reclaimed are also discussed in Chapter 4 and would not change under the low-level scenario.

Topography would be changed only slightly by coal-related development and at mine support facility sites (average of 200 acres per mine). The main impact of these activities would be at cut and fill sites to maintain grade along access roads and railroads. Acres disturbed by roads and railroads under the low-level scenario would be 3,756 acres in 1980 (141 less than at the probable level), and 4,596 acres in 1985 and 1990 (141 less than at the probable level).

Disturbance would occur along 187 miles of access roads and railroads in 1980 and 227 in 1985 and 1990 (8 less than at the most probable level of 195 miles in 1980 and 235 in 1985 and 1990).

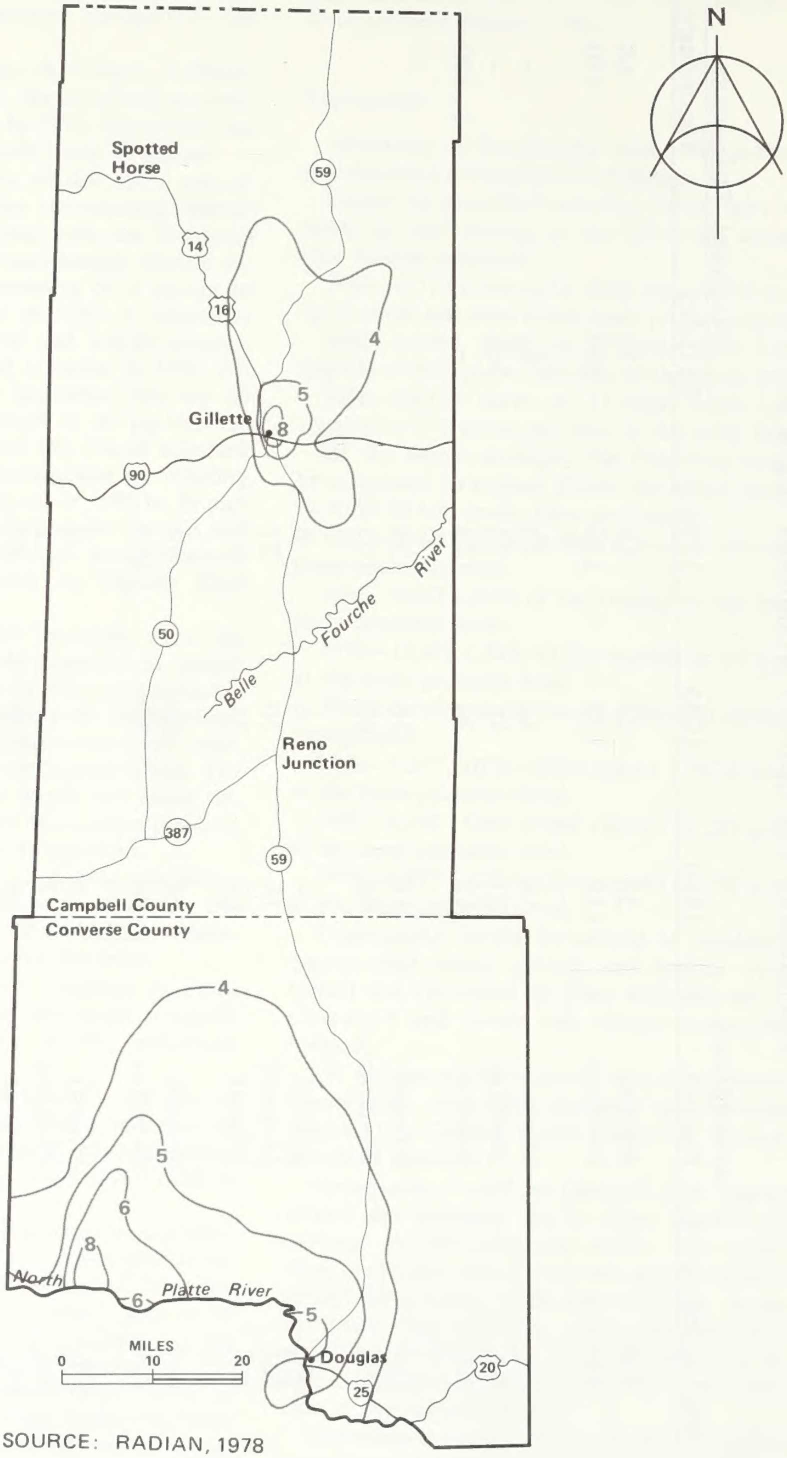
Figures for total acres disturbed by all regional development may be found in Table R8-4 for the low-level scenario.

TABLE R8-8

ANNUAL AND MAXIMUM SHORT-TERM CONCENTRATIONS ($\mu g/m^3$) PREDICTED AROUND TOWNS IN THE REGION FOR THE LOW-LEVEL SCENARIO WITH THE NATIONAL AND WYOMING AIR QUALITY STANDARDS ($\mu g/m^3$)

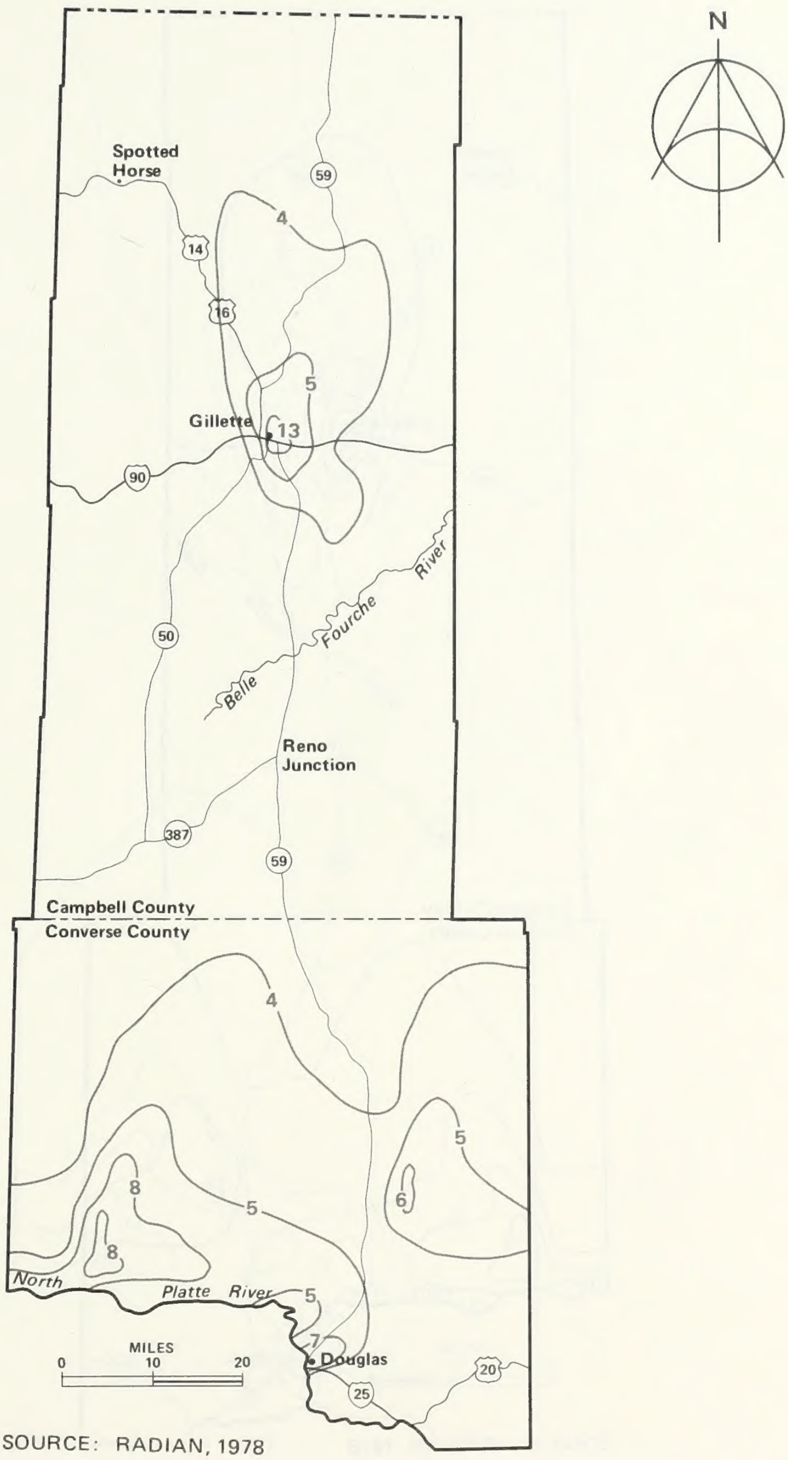
Town	Pollutant	Averaging Period	1980	1985	1990	National Standards Primary	National Standards Secondary	Wyoming Standard
Gillette	TSP	Annual	35	35	40	75	60	60
	TSP	24-hour	119	119	136	260	150	150
	SO_2	Annual	8	13	23	80	-	60
	SO_2	24-hour	27	44	78	365	-	260
	SO_2	3-hour	45	73	129	-	1,300	1,300
Moorcroft	TSP	Annual	26	26	30			
	TSP	24-hour	88	88	102			
	SO_2	Annual	4	6	8			
	SO_2	24-hour	14	20	27			
	SO_2	3-hour	22	34	45			
Douglas	TSP	Annual	26	27	30			
	TSP	24-hour	88	92	102			
	SO_2	Annual	5	7	8			
	SO_2	24-hour	17	24	27			
	SO_2	3-hour	28	39	45			
Glenrock	TSP	Annual	27	30	30			
	TSP	24-hour	92	102	102			
	SO_2	Annual	8	8	8			
	SO_2	24-hour	27	27	27			
	SO_2	3-hour	45	45	45			

Note: Standards for averaging times less than one year are not to be exceeded more than once a year.



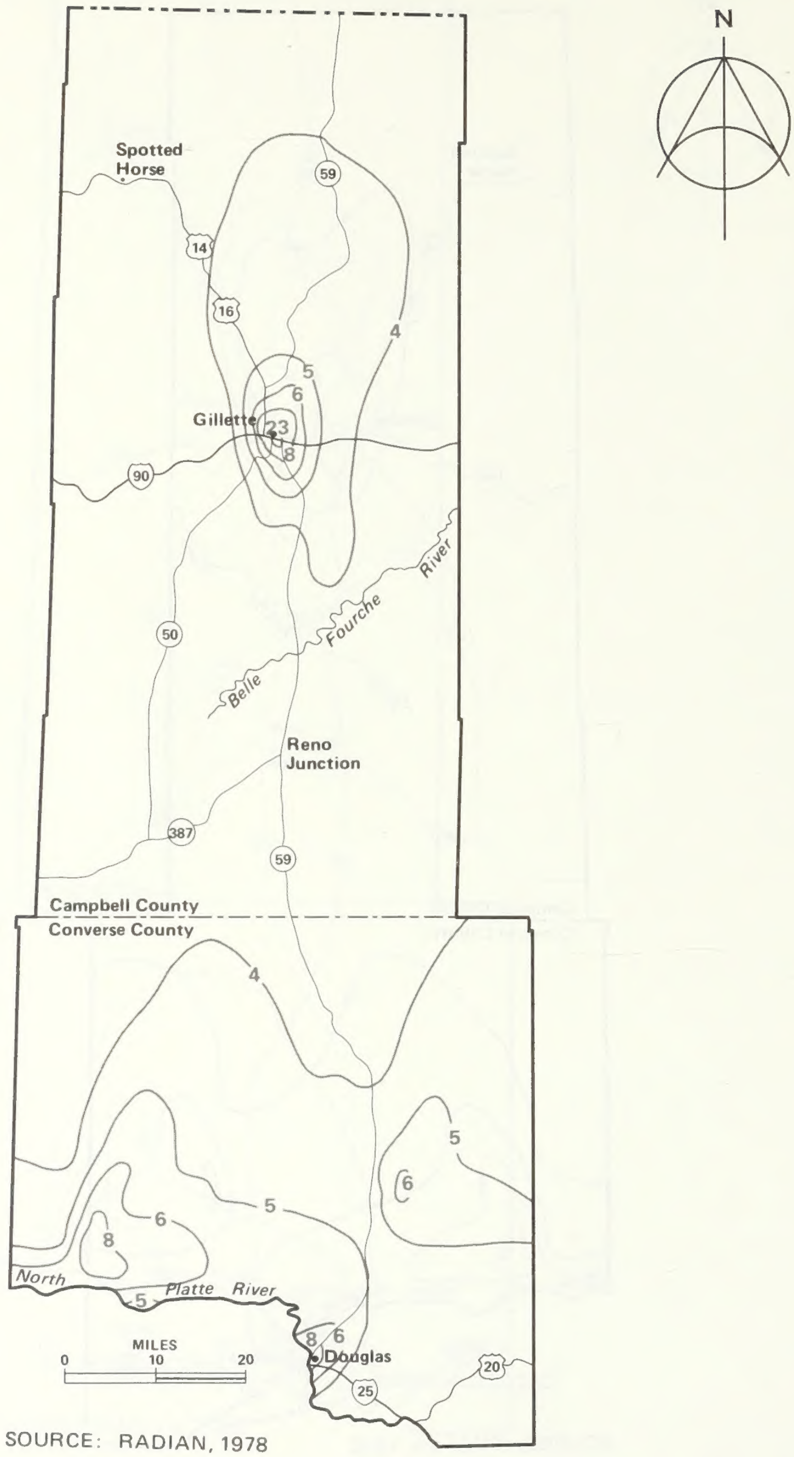
SOURCE: RADIAN, 1978

Figure R8-4
ANNUAL SO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE LOW LEVEL SCENARIO FOR 1980



SOURCE: RADIAN, 1978

Figure R8-5
ANNUAL SO_2 CONCENTRATIONS ($\mu g/m^3$)
FOR THE LOW LEVEL SCENARIO FOR 1985



SOURCE: RADIAN, 1978

Figure R8-6

ANNUAL SO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE LOW LEVEL SCENARIO FOR 1990

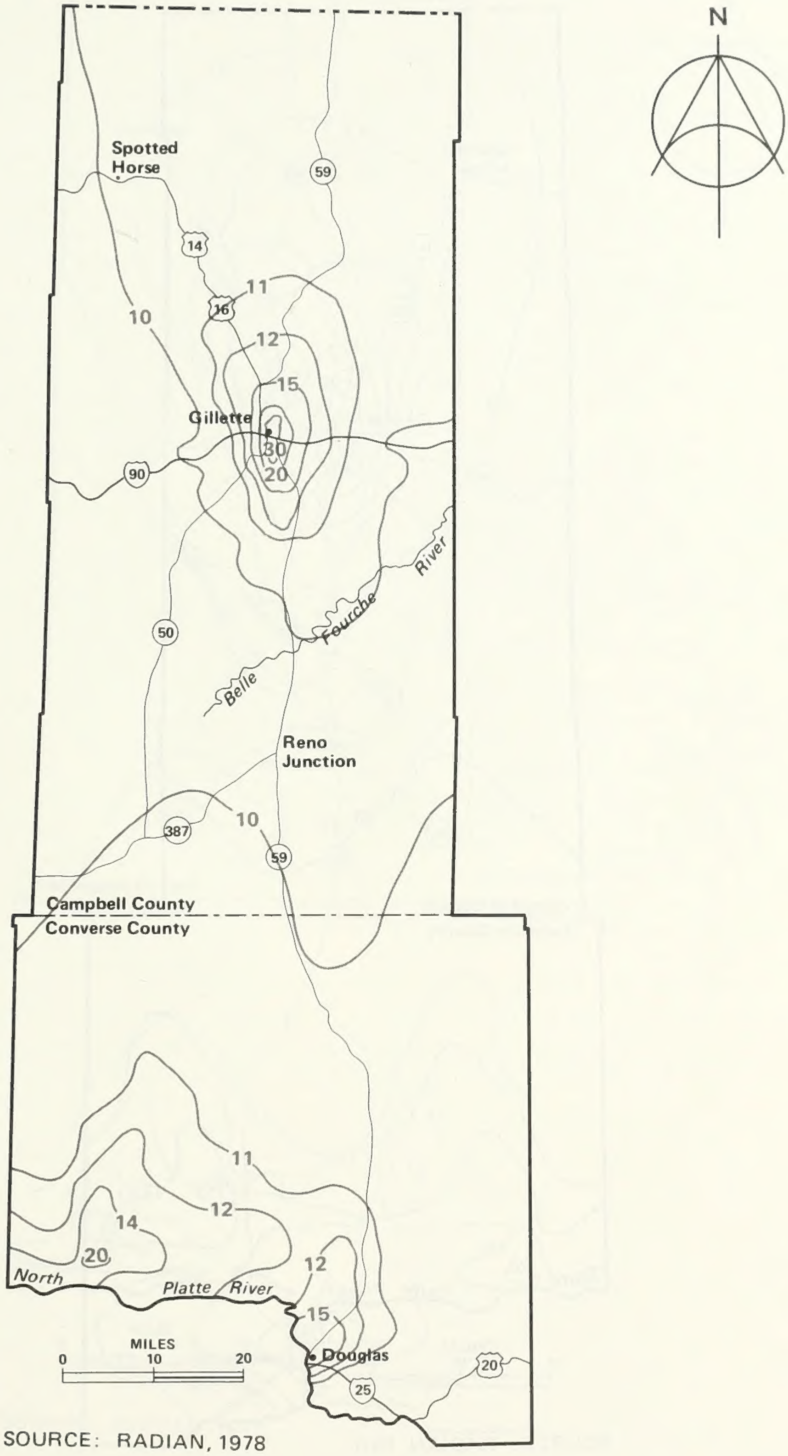


Figure R8-7

ANNUAL NO_2 CONCENTRATIONS ($\mu g/m^3$)
FOR THE LOW LEVEL SCENARIO FOR 1980

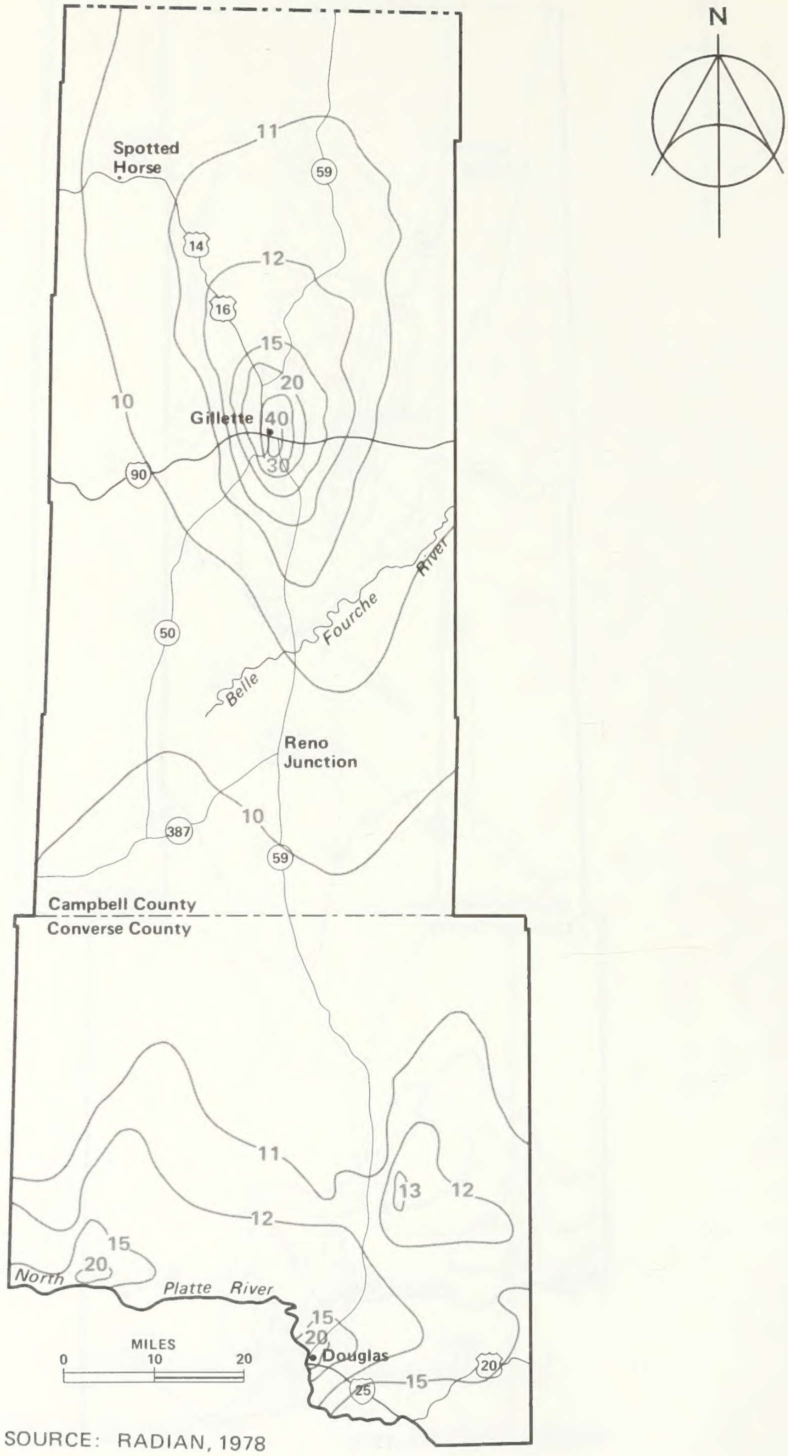


Figure R8-8

ANNUAL NO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE LOW LEVEL SCENARIO FOR 1985

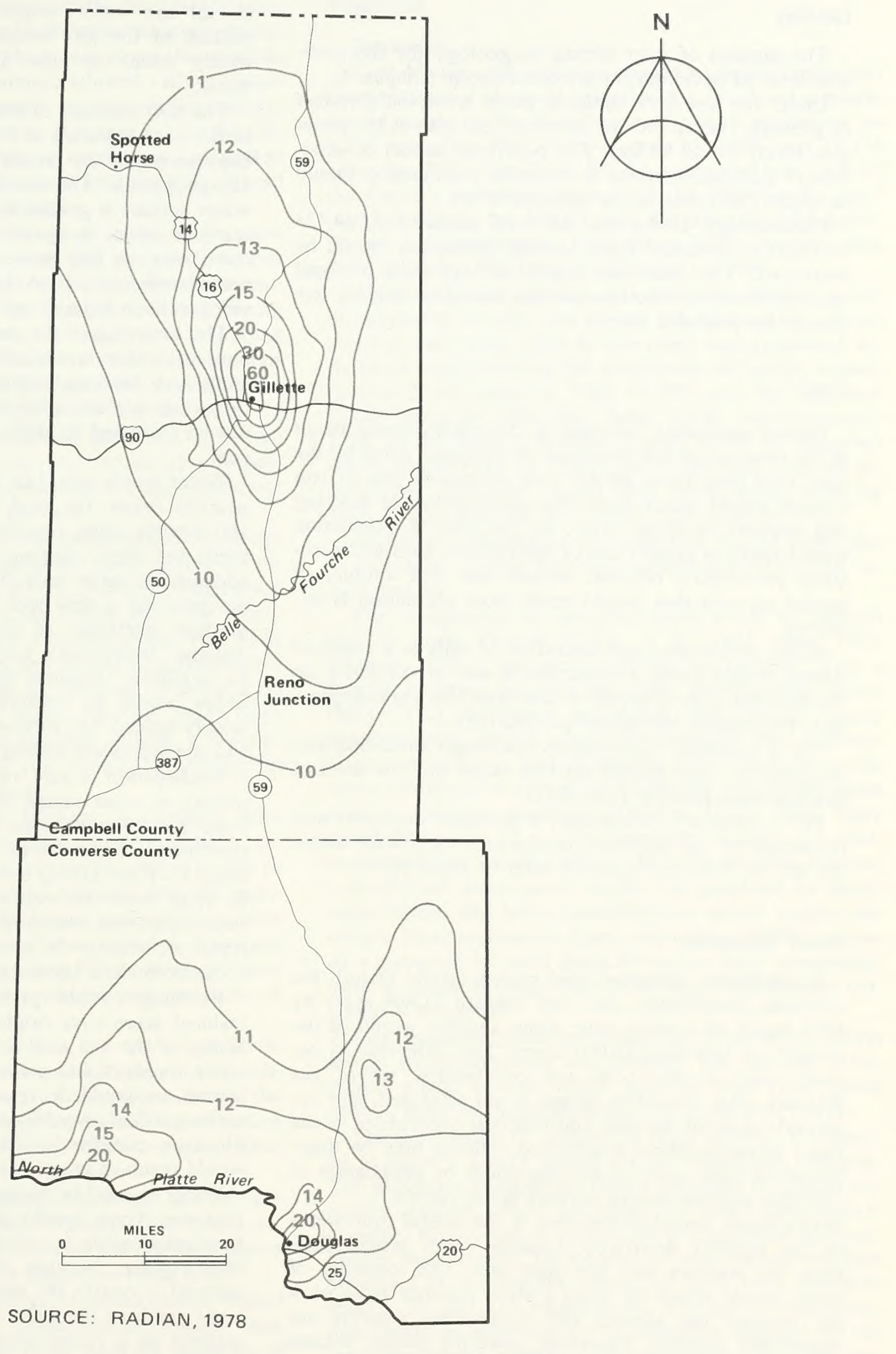


Figure R8-9
ANNUAL NO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE LOW LEVEL SCENARIO FOR 1990

Geology

The impacts of strip mining on geology for the probable level of development are described in Chapter 4.

Under the low level scenario about 8,984,438 acre-feet of geologic record (90,562 acre-feet less than at the probable level) would be lost. The beneficial impact of exposure of geologic sections to scientific examination would be slightly less than at the probable level.

Paleontology. Under the low-level scenario, 8,984,438 acre-feet of potential fossil-bearing formations would be destroyed. The beneficial impact of exposure of fossil materials for scientific examination would be slightly less than at the probable level.

Soils

Future population increases in the region would result in the removal of soil from several thousand acres by the year 1990 (see Table R8-4). This permanent loss of soil surface would result from the construction of housing and support facilities. Also, an increase in population would result in greater use of the region's soils for recreation, particularly off-road vehicle use. The amount of impact on soils that would result from recreation is unknown.

Major disturbance and alteration of soils as a result of mining would cause a reduction in soil productivity on the affected soils. Chapter 4 describes the various processes resulting in loss of soil productivity.

For a summary of cumulative acreages disturbed and reclaimed by coal mining activity under the low level of development, refer to Table R8-3.

For a summary of cumulative acreages disturbed and reclaimed by all regional development activities under the low level of development, refer to Table R8-4.

Water Resources

Groundwater. Although coal mining would disturb the alluvium, overburden, and coal beneath 21,664 acres by 1990, based on existing mine plans, aquifers would be destroyed on less than 18,900 acres. The difference is because part of the coal and overburden where the Wyodak seam would be mined is not saturated, and apparently none of the coal and bedrock overburden at the Dave Johnston Mine is saturated. Mining may be disallowed on some parts of existing mines by application of SMCRA regulations; the acreage is not known.

Water levels would be lowered in the lateral equivalents of the aquifers destroyed, because water would flow from the aquifers into the mine pits. The lowering of water levels would be small a short distance from each pit, because the alluvial and overburden aquifers are water-table aquifers. Therefore, lowering cannot exceed the thickness of the individual aquifers, and lowering which approximates the aquifer thickness would occur only at the face of a pit.

Water in the coal is, in places, under artesian conditions. Where these conditions occur, water levels could be lowered more than the thickness of the coal. However, all the water would not necessarily drain to the bottom of the pit, because shale partings, which commonly occur in coal, impede vertical movement of water.

The best example of impacts of mining on water levels in the coal is shown in Figure R2-10. The two northern depressions in the water-level surface are natural discharge points. The southern depression is where the water surface is graded toward the Wyodak Mine. There are nine mines in operation or under construction, and there may be five more by 1985. A depression in the water surface, such as that west of Wyodak, would develop at each mine except Dave Johnston.

The lowering of the water level in the coal and overburden aquifers would affect water levels in some nearby wells and decrease natural discharge. However if wells or springs are adversely impacted by mining, the impact can be mitigated by drilling wells into aquifers below the coal.

Water levels would be lowered an unknown amount in aquifers below the coal by development for municipal and potable mine supplies. Gillette has determined that their well field, tapping the Fort Union Formation, is adequate to serve only the present population, and they are planning a new well field, tapping the Madison Limestone northeast of Gillette to supply the increased demand. Interference between wells of the mines would be negligible, because potable supplies required at the mines would be relatively small, the wells would be widely spaced, the formations beneath the coal are thick, and the individual aquifers are lenticular.

Reclamation would begin within 2 to 3 years after mining at most mines, and the long-term groundwater conditions would begin to be established. Water-table conditions would occur in the reclaimed areas, and a study by Rahn (1976) indicates that the spoil may be able to yield water as well as the aquifers it replaces. The small seeps that occurred on some hillsides would not be replaced, because the spoil would not have the relatively continuous shale layers that resulted in perched water.

Recharge would probably be increased in the reclaimed areas over original levels. Although the permeability of the soil may decrease, reclamation practices to retain moisture and prevent erosion would increase infiltration, as would decrease in the mean slope of the land surface, which would generally occur. An increased infiltration, combined with destruction of the shale layers, would result in greater recharge.

Water in spoil in the reclaimed areas south of the Belle Fourche River would probably have nearly the same head relationship to adjoining aquifers as do the aquifers they replace, because the land surface would be reclaimed to nearly the same elevation. In some reclaimed areas north of the Belle Fourche, the land would be reclaimed to a lower elevation than that of the original water level in the coal, and the original conditions could not be restored. In reclaimed areas north and east of Gillette the discharge points from the coal would be the new edge of coal. However, the shape of the water surface would be essentially the same as shown in Figure R2-10.

Where broad, low-lying areas remain after reclamation in discharge areas, there would probably be more opportunity for subirrigation than there was along the original, or would be along the reclaimed, alluvial valleys. Some streams may become perennial or intermittent downstream from the reclaimed areas, if recharge is in fact increased. If there is less bulking of spoil than anticipated or if there is long-term compaction, waterlogging of land could be the major adverse impact.

The quality of water in the spoil in recharge areas would be poorer than the quality that occurred in most of the preexisting aquifers. However, because the chemical environment would not be changed in the adjoining aquifers, water moving from the spoil into adjoining aquifers would undergo reactions such that common ions and trace elements dissolved in the water would be the same as before mining a short distance from the mine.

In areas where bedrock aquifers, including coal, discharge into spoil, the water moving into the spoil would increase in dissolved constituents, and it would be similar to that in alluvial aquifers in the area.

One coal gasification project is anticipated to be in operation by 1990. Large quantities of water would be required (see Tables R8-5 and R1-7), and the groundwater sources being considered include water from the Madison Limestone and the Lance Formation and Fox Hills Sandstone. Until the quantity and source of groundwater that would be used is known, no estimate of impacts on groundwater supply can be made. Further, other environmental impacts cannot be assessed without a description of what by-products, if any, would be allowed to enter into the hydrologic system.

The impacts of uranium mining, particularly with regard to potential hazard to quality of groundwater, require additional study. However, in the southern part of the region, which is the principal uranium area, the sandstone aquifers are, apparently, better aquifers than those to the north. Also, ranchers have reported (personal communications) that mining and milling operations have caused decreased flow in one stream and cessation of flow in at least one well.

The impacts on water resources are not all negative, however, as dewatering of one uranium mine has resulted in perennial flow in a reach of the stream below the mine. This has benefited agriculture by making irrigation possible along the stream. Similar conditions may occur elsewhere with the opening of new mines.

Groundwater use for irrigation, secondary and tertiary recovery of oil, and stock and domestic use is not expected to increase. Projected water use for the region with low-level development is shown in Table R8-5.

Surface Water. The low level of development would result in a level of impact insignificantly smaller than that shown in Chapter 4. See Table R4-4 for estimates of some impacts. Those headed "all activity"are essentially the same as those of the low-level scenario; the differences (due to Buckskin Mine activity) are so small that they are well within the errors of the predicted values.

Vegetation

Terrestrial.

Coal Mining. All activities related to development and continuation of the coal mines in the low-level scenario would result in the disturbance of native vegetation on 8,119 acres by 1980, 16,084 acres by 1985, and 22,136 acres by 1990. (See Table R8-3.) Approximately 0.4% of the region's surface acreage would be disturbed by existing coal activity by 1990. Lands disturbed by coal activity and reclaimed would total about 3,495 acres by 1980, 9,887 acres by 1985, and 12,652 acres by 1990.

All Development Activity. All activities related to the development of new coal mines, the continuation of the existing coal mines, plus all the other energy-related activities would result in the disturbance of native vegetation on 22,872 acres by 1980, 41,293 acres by 1985, and 52,045 acres by 1990 (see Table R8-4). Approximately 1.0% of the region's surface acreage would be disturbed by all this activity by 1990. Lands disturbed from all activity and reclaimed would total about 4,895 acres by 1980, 13,437 acres by 1985, and 18,952 acres by 1990.

Additional disturbance of vegetation would occur due to increased outdoor recreation (particularly off-road vehicle travel).

The revegetation of disturbed areas would be difficult due to many factors (Cook et al. 1974, May 1975, Thames 1977). Climatic conditions are severe, with a lack of moisture possibly being the most limiting factor (May 1975). Secondary succession plant species would compete with seeded plants for moisture and nutrients (James and Cronin 1974, Klingman 1971). Rodents would cause problems on revegetated areas by consuming seeds and by girdling seedlings (Thames 1977). Also there could be a loss of soil productivity as soils are rearranged, which would further limit revegetation success.

Reclaimed areas would usually be grassland for many years. Shrub and forb reestablishment would require extensive plant succession. Cook and others (1974) suggested a period of 10 to 30 years for native plant reestablishment in semiarid rangelands (providing supplemental irrigation is not used).

Young, palatable plants produced by revegetation efforts would attract livestock and wildlife. The grazing of the young plants would inhibit growth vigor and could cause a delay in the establishment of vegetative cover.

The destruction of vegetation from wildfire is expected to cause a yearly impact on the vegetation resource. The incidence of lightning fires is expected to remain relatively constant, while the number of man-caused fires is expected to increase in proportion to population increase. Within that premise, the number of man-caused wildfires projected for benchmark periods of 1980, 1985, and 1990 are 77, 95, and 112 respectively. Acreage of vegetation that would be destroyed by all wildfires annually for the same benchmark periods is estimated at 4,515, 5,545, and 6,568 acres respectively.

Haul road dust and fugitive coal dust resulting from mining operations may be deposited on vegetation adjacent to the mine areas. Dust-covered vegetation would be less palatable to livestock and wildlife.

Another impact from the destruction of vegetative cover could be the invasion of noxious weeds or other less palatable species of vegetation onto the disturbed areas. These weedy species would compete with seeded species and could inhibit the establishment of desired permanent vegetative cover.

The short-term and long-term losses of vegetative cover and production from disturbance activities would affect numerous living and nonliving components of the environment (see other sections in this chapter).

Aquatic. Aquatic habitats that would be impacted by mineral developments are not extensive. Mining would eliminate aquatic habitats in certain localized areas (see the site-specific analysis). In nearby offsite areas, aquatic habitats in groundwater-fed ponds would probably be eliminated due to lowered aquifer levels.

Surface runoff from disturbed areas could increase the sediment load into streams. This increase would degrade the aquatic community and destroy individual plants by suffocation and the abrasive effects of increased siltation.

Endangered and/or Threatened Species. There is no record of any endangered or threatened plant species in the region; therefore no impact would be anticipated.

ish and Wildlife

Table R8-9 summarizes the impacts on fish and wildlife habitat and populations by the fourteen existing mines and the cumulative total of all regional development including the coal mines. See Chapter 4, Fish and Wildlife, for a detailed analysis of the effects of development on fish and wildlife habitat and populations.

Cultural Resources

The number of sites which may be disturbed or destroyed by activities under the low-level scenario cannot be quantified at this time; however compliance with Executive Order 11593 and Section 2(b) of the Historic Preservation Act would ensure mitigation of impacts of cultural resources which may be affected by much of the development activity.

Visual Resources

Regional development in the low-level scenario would affect visual resources in the region to an insignificantly slighter degree than the probable level of development. Those alterations in the landscape expected through 1990 are discussed in Chapter 4.

Recreation Resources

Compared with the probable level of development, the low-level scenario would reduce projected regional (Campbell and Converse counties) population increases, and hence recreation participation, by only 4% by 1990. This difference would be considered negligible both by residents of the region and by agencies and municipalities responsible for providing and maintaining recreation facilities. Changes already occurring in recreation styles and participation are discussed in Chapter 4.

Agriculture

Livestock Grazing.

Coal Mining. All activities related to the development and continuation of coal mining in the low-level scenario would remove vegetation from an estimated 8,119, 16,084, and 22,136 acres by 1980, 1985, and 1990 respectively. Livestock forage lost due to these activities would be 1,624 animal unit months (AUMs) by 1980, 3,217 AUMs by 1985, and 4,427 AUMs by 1990. (See Table R8-3.)

All Development Activity. All activities related to the development and continuation of the coal mines, plus all the other energy-related activities would remove native vegetation from an estimated 22,872, 41,293, and 52,045 acres by 1980, 1985, and 1990 respectively. Livestock forage lost due to these activities would be 4,574 AUMs by 1980, 8,258 AUMs by 1985, and 10,409 AUMs by 1990.

The loss of AUMs due to these activities would be detrimental to the region's livestock industry but would not significantly affect production of livestock, since the majority of the AUMs would not be permanently lost. Reclamation would be conducted on an estimated 36% (18,952 acres) of the acreage which would be disturbed by 1990 (52,045 acres or 1.1% of the region's acreage).

Besides direct loss of livestock forage, other impacts associated with population increases, as discussed in Chapter 4, could occur.

The development of mines and the construction of facilities such as access roads and rail spurs would divide grazing areas, disrupt grazing-use patterns, cause access problems to livestock water areas, increase the costs of caring for the livestock, and possibly alter land ownership patterns.

Mine development could cause some loss of stock watering facilities for the duration of mining activities. This could result in nonuse of grazing areas, if their location is remote from remaining water sources. Wells developed on mining sites for use in mine operations could be put to beneficial use in livestock operations when the disturbed lands are reclaimed and returned to full production.

Fugitive dust from overburden material could contain trace elements toxic to plants and/or animals. Long-term contamination of adjacent rangelands could result (Thames 1977).

Farming. The development of energy-related minerals at the low-level scenario would result in the loss of crop-producing lands as shown in Table R8-10.

Prime and Unique Farmland. As yet there are no areas delineated in the region as prime farmland (see Chapter 4, Agriculture, Prime and Unique Farmland).

TABLE R8-9

SUMMARY OF ADVERSE IMPACTS TO WILDLIFE
LOW-LEVEL SCENARIO

			Estimated Individuals Lost							
		Habitat	Fishery		Birds			Mammals		
									Game	
		Loss (Acres)			Nongame	Game*	Raptors	Nongame	Antelope	Deer
Coal Mining	1980	8,119			41,407	1,656	46	30,852	264	38
	1985	16,084	2 Streams 9½ Miles	2 Reservoirs 71 Total Acres	82,028	3,280	90	61,119	523	75
	1990	22,136			112,894	4,514	125	84,117	719	103
Total of All Activities	1980	22,872			116,647	4,664	129	86,914	743	107
	1985	41,293	2 Streams 9½ Miles	2 Reservoirs 71 Total Acres	210,594	8,420	232	156,913	1,342	194
	1990	52,045			265,430	10,612	293	197,771	1,691	244

* Only doves.

TABLE R8-10

SUMMARY OF PROJECTED LOSS OF AGRICULTURAL LAND AND PRODUCTION AT LOW-LEVEL SCENARIO

	Land Removed From Crop Production (Based On Total Acres Disturbed)		Annual Hay Production Lost (Tons)			Annual Dryland Wheat Lost (Bushels)	Other Cropland Lost (Acres)	
Year	(Acres) Dryland	(Acres) Irrigated	Dryland .78 Tons/Acre	Irrigated 1.62 Tons/Acre	Total Tons	18.6 Bushel/Acre	Dryland	Irrigated
1980								
Coal Mining	162	48	67	58	125	1,089	18	12
All Activities	534	158	220	192	412	3,576	59	39
1985								
Coal Mining	237	70	98	85	183	1,588	26	17
All Activities	892	264	368	322	690	5,975	99	65
1990								
Coal Mining	480	142	198	173	371	3,216	53	35
All Activities	1,179	349	486	425	911	7,897	131	86

Mineral Resources

Under the low-level scenario, coal resources consumed in 1979-80 would be 178 million tons (4 million tons less than under the probable level); from 1981-1985, coal resources consumed would be 735 million tons (about 14 million tons less at than the probable level); and from 1986-1990, 846 million tons would be consumed (20 million tons less than at the probable level). By 1990, more than 1,852.38 million tons (2.5% of the minable and 8.9% of the strippable coal resources of the region) would have been consumed. Consumption of other mineral resources such as uranium, sand, gravel, and scoria is discussed in Chapter 4, and there would be no change in those estimates for the low-level scenario.

Transportation Networks

Railroads. Coal and noncoal freight trains flowing through or out of the Eastern Powder River Basin under the low-level scenario is shown in Tables R8-11 and R8-12. Impacts of railroad traffic on communities which lie along the railroad lines would be slightly (less than 2 trains per day) less than those described in Chapter 4.

Highways. The following highway improvements are planned for northeastern Wyoming whether or not additional coal development occurs. Future freeway improvement would include the completion of the unfinished portion of Interstate 25 and second-stage surfacing and upgrading as necessary. Federal and state highways would be upgraded and improved as necessitated by increases in use. U.S. Highway 26/87 would be improved southeast of Orin Junction for 2.5 miles with grading, drainage structures, and paving. The bridge over Spotted Horse Creek, northwest of Gillette, is scheduled for replacement on U.S. Highway 14/16.

State Highway 59 would be widened and surfaced from Reno Junction north for 8 miles. State Highway 387 would be widened and improved for 6.6 miles east from the Johnson County line. This project would include grading, drainage structures, and asphalt. Extension of State Highway 450 (Clareton Road) from Clareton to Reno Junction is proposed. As part of the project, grading, drainage structures, and asphalt are planned from Highway 59 east for 15 miles and from the Weston County line west for 6 miles. The total proposed length of the new road is 35 miles, and its purpose is to disperse the work forces and population from Gillette and Reno Junction to the Upton and Newcastle area (personal communication, Oliver Sundby, Wyoming Highway Department 1977), and to provide better access to the coal fields. This project would be partially funded by the coal companies, and was a mitigating measure from the previous Eastern Powder River Basin Environmental Statement (FES 74-55).

In addition to being maintained and improved, county roads would be expanded as the population increases in rural areas. The county would take over, develop, improve, and maintain existing private roads as expansion needs require; and also build new roads to serve growth areas, especially in those areas that require school bus service. Bureau of Land Management and Forest Service roads would be upgraded as deemed feasible and necessary because of increased use for recreation.

There were 109,629 registered cars and trucks in 1975, or almost one car or truck for each person living in the eight northeastern counties of Wyoming in 1975. (Based upon a total 1975 population of 115,900, total car and truck registrations amounted to 95% of population figures.) Projections for the low-level scenario were made for 1980, 1985, and 1990 upon the assumption that the basic percent relationship between vehicle registrations and population within the region would remain constant. By 1980, 1985, and 1990, there would be 128,137, 154,231, and 172,118 increase in registered vehicles respectively in the eight counties (Table R8-13).

Air Service. Two regional airports are planning expansion or improvements to handle current demand, as well as that projected under the low-level scenario.

In 1976, Converse County finished a $30,000 survey on moving the county airport to a different site 2 miles north of Douglas, where there would be more room for expansion if needed. If approved, and if federal funds are available, the new facility would be completed sometime between 1980 and 1985. The new facility would have two runways, one with a length of 7,000 feet and enough room to expand 2,000 feet, and another with a length of 5,000 feet (Harbridge House 1976).

In Campbell County, the Gillette-Campbell County Airport has applied for a planning grant from the Federal Aviation Administration to see what changes are needed in the future, which could include changing the location of the airport. If approved, the study would be completed in 12 to 18 months. Demand forecasts and present inventories, which would determine the adequacy or inadequacy of the present site, should be completed after 4 months. Present problems with the Gillette-Campbell County facility include: limitations of the ramp area and overall facility, 1,300 feet of unusable runway (because of ground upheaval), and out-of-date instrument approaches. Also, the airport is 300 feet below the surrounding terrain, which causes fog to lie in over the airport. Currently new and improved navigation and communication equipment is being installed. It is hoped an advanced instrument landing system can be installed in the future (personal communication, Sam Stafford 1977).

All airports in northeast Wyoming would be upgraded as increased demands on the facilities dictate and as necessary funds become available.

Other. Impacts of the low-level of coal development on bus service would be virtually indistinguishable from those discussed in Chapter 4.

Socioeconomic Conditions.

Sociocultural Impacts. The lower population level projected for the low-level scenario would mean sociological impacts that are slightly reduced from those outlined in Chapter 2 and 4. The relationship would not necessarily be proportionate. That is, all impacts would probably not decrease by the same percentage as the population change, because some impacts tend to compound them-

TABLE R8-11

ANNUAL UNIT COAL TRAIN VOLUME
LOW-LEVEL SCENARIO

	1980 Number of Unit Trains*	1985 Number of Unit Trains	1990 Number of Unit Trains	Market Destination**
Existing Mines				
Operating Mines				
Wyodak	45***	45***	45***	South Dakota, mine mouth (Wyodak Power Plant)
Dave Johnston	0***	0***	0***	Mine mouth (Dave Johnston Power Plant)
Belle Ayr	1,600	1,900	1,900	Colorado, Texas, Indiana, Missouri, Kansas, Oregon, Arkansas
Cordero	2,000	2,400	2,400	Texas, Wyoming
Rawhide	900	1,200	1,200	Nebraska, Indiana
Black Thunder	1,370	2,000	2,000	Nebraska, Oklahoma, Texas
Jacobs Ranch	1,070	1,570	1,540	Arkansas, Louisiana, Oklahoma
Eagle Butte	1,320	2,000	2,000	Southern, Midwestern, and Ohio Valley states
Kerr-McGee #16	420	420	420	Unknown

TABLE R8-11
(cont'd)

ANNUAL UNIT COAL TRAIN VOLUME
LOW-LEVEL SCENARIO

	1980 Number of Unit Trains*	1985 Number of Unit Trains	1990 Number of Unit Trains	Market Destination**
Environmental Statement in Progress				
Caballo	300	700	1,200	Unknown
Coal Creek	400	1,000	1,000	Unknown
East Gillette	400	1,100	1,100	Arkansas, Louisiana
Rochelle	0	0***	0***	Wyoming
Pronghorn	350	500	500	Unknown
Total	10,175	14,835	15,305	

1980 daily average = 10,375 trains per year ÷ 365 = 28.4 trains per day eastbound (loaded)
28.4 trains per day westbound (empty)

1985 daily average = 14,835 trains per year ÷ 365 = 40.7 trains per day eastbound (loaded)
40.7 trains per day westbound (empty)

1990 daily average = 15,305 trains per year ÷ 365 = 42.0 trains per day eastbound (loaded)
42.0 trains per day westbound (empty)

Source: Table R1-2.

* A unit coal train usually consists of 100 coal cars and 5 diesel units. Each car carries 100 tons of coal.

** Based on Western Oil Reporter February 1978.

*** This number does not represent full transport of the mine production by unit trains. Coal consumed at mine mouth is generally transported short distances by truck or private rail.

TABLE R8-12

DAILY TRAIN VOLUME PROJECTIONS FOR THE REGION
LOW-LEVEL SCENARIO

Train Type	1980* Number of Trains**	1980* Percent of Total	1985 Number of Trains**	1985 Percent of Total	1990 Number of Trains**	1990 Percent of Total
Northern Route						
Total Coal Trains:	66.8	91.8	54.7	90.1	56.0	90.3
Eastern Powder River Basin Coal Trains***	55.8	76.7	43.7	72.0	45.0	72.6
"Other" Coal Trains****	11.0	15.1	11.0	18.1	11.0	17.7
Non-coal Freight Trains*****	6.0	8.2	6.0	9.9	6.0	9.7
Total Coal and Non-coal Freight Trains	72.8	100.0	60.7	100.0	62.0	100.0
Southern Route						
Total Coal Trains:	0	0	43.7	84.5	45.0	84.9
Eastern Powder River Basin Coal Trains***	0	0	43.7	84.5	45.0	84.9
"Other" Coal Trains	0	0	0	0	0	0
Non-Coal Freight Trains	8	100.0	8.0	15.5	8.0	15.1
Total Coal and Non-Coal Freight Trains	8	100.0	51.7	100.0	53.0	100.0

* Train traffic expected on the Burlington Northern route in early 1980 before the Donkey Creek to Orin Junction rail strip is completed. If the rail strip were completed in 1980, about half of the coal trains originating in the Eastern Powder River Basin would move south toward Orin Junction.

** Includes both loaded and empty train traffic.

*** See Table R1-2.

**** Burlington Northern estimate of coal trains in Gillette in 1982, personal communication, Jerrold G. Wood, Director of Public Works 1978.

***** Burlington Northern freight traffic estimate for the Donkey Creek to Edgemont rail segment in 1978 and 1982, personal communication, Jerrold G. Wood, Director of Public Works 1978.

TABLE R8-13
POPULATION PROJECTIONS, 1978-1990
LOW-LEVEL SCENARIO

County City	1978	1980	Annual Rate of Change* 1978-1980	1985	Annual Rate of Change* 1980-1985	1990	Annual Rate of Change* 1985-1990	Annual Rate of Change* 1978-1990
Campbell	16,000	18,045	(6.2)	23,798	(5.7)	28,773	(3.9)	(5.0)
Gillette	10,067	11,875	(8.6)	17,625	(8.2)	22,600	(5.1)	(7.0)
Other Areas	5,933	6,170	(2.0)	6,173	**	6,173	**	(0.3)
Converse	9,543	10,912	(7.0)	18,958	(11.7)	17,619	(-1.5)	(5.2)
Douglas	4,824	5,692	(8.6)	12,330	(16.7)	10,919	(-2.4)	(7.0)
Glenrock	2,296	2,733	(9.1)	4,138	(8.7)	4,210	(0.3)	(5.2)
Other Areas	2,483	2,487	**	2,490	**	2,490	**	**
Crook	5,148	5,434	(2.7)	6,292	(3.0)	6,809	(1.6)	(2.4)
Moorcroft	1,200	1,482	(11.1)	2,334	(9.5)	2,851	(4.1)	(7.5)
Other Areas	3,948	3,952	**	3,958	**	3,958	**	**
Johnson	6,803	6,862	(0.4)	7,212	(1.0)	7,624	(1.1)	(1.0)
Buffalo	4,400	4,455	(0.6)	4,799	(1.5)	5,211	(1.7)	(1.4)
Other Areas	2,403	2,407	**	2,413	**	2,413	**	**
Natrona	58,000	59,377	(1.2)	67,294	(2.5)	76,491	(2.6)	(2.3)
Casper	47,222	48,595	(1.4)	56,506	(3.1)	65,703	(3.1)	(2.8)
Other Areas	10,778	10,782	**	10,788	**	10,788	**	**
Niobrara	3,020	3,045	(0.4)	3,133	(0.6)	3,219	(0.5)	(0.5)
Lusk	2,000	2,021	(0.5)	2,103	(0.8)	2,189	(0.8)	(0.8)
Other Areas	1,020	1,024	**	1,030	**	1,030	**	**
Sheridan	22,501	23,713	(2.7)	27,347	(2.9)	31,666	(3.0)	(2.9)
Sheridan	13,400	14,608	(4.4)	18,230	(4.5)	22,549	(4.3)	(4.4)
Other Areas	9,101	9,105	**	9,117	**	9,117	**	**
Weston	6,932	7,493	(4.0)	8,315	(2.1)	8,976	(1.5)	(2.2)
Newcastle	3,455	4,012	(9.8)	4,828	(3.8)	5,489	(2.6)	(4.0)
Other Areas	3,477	3,481	**	3,487	**	3,487	**	**
Region	127,977	134,881	(2.7)	162,349	(3.8)	181,177	(2.2)	(2.9)

Source: University of Wyoming 1978.
* Average rate of change compounded annually.
** Average rate of change less than 0.1 %.

selves and add to other impacts. The degree of impact reduction is therefore difficult to predict.

Economic Impacts.

Population. Table R8-13 contains local and regional low-level scenario population projections. Since the actual level of coal development in the Eastern Powder River Basin is likely to be much higher than that foreseen under the low-level scenario, these estimates could be regarded as a lower limit to future population growth in northeastern Wyoming.

Despite the conservative assumptions made regarding future levels of coal development, the projections in Table R8-13 foresee a continued rapid growth in the population of Campbell County and Gillette between 1978 and 1990. During this period Campbell County's population is anticipated to grow from 16,000 to 28,773, an average annual rate of change of 5.0%. Gillette, meanwhile, would grow from 10,067 to 22,600 inhabitants (an average 7.0% annual increase). Both the county and Gillette would experience their most rapid rate of annual population increase between 1978 and 1980 (6.2% and 8.6% per year respectively), declining gradually thereafter.

Converse County and the towns of Douglas and Glenrock would experience major population growth during the period under study, largely as a result of the projected coal gasification plant to be built northeast of Douglas. This population boom is expected to peak around 1985, when Converse County would have a population of nearly 19,000, and Douglas would have over 12,000 inhabitants. Thereafter, Converse County and Douglas both would face a decline in population as the coal gasification plant's large construction work force is disbanded and replaced with a smaller operating staff. Glenrock, which would receive fewer of the gasification plant construction workers, would experience a somewhat slower population growth rate (5.2% annually between 1978 and 1990), but would avoid a drop in population after the gasification plant is completed in 1985-1986. However, population growth in Glenrock would level off at only 0.3% annually between 1985 and 1990.

Crook County and the town of Moorcroft would also experience significant population growth under the low-level scenario. The population of Crook County should grow from 5,148 to 6,809 between 1978 and 1990 (an increase of 2.4% annually), while Moorcroft would be expected to grow from 1,200 to 2,851 inhabitants over the same period (an average annual increase of 7.5%). The projected population of other counties and municipalities would not differ substantially from that discussed in Chapter 4.

Employment. Table R8-14 contains low-level scenario employment projections for the eight-county region. Summarizing, business and consumer services would remain the predominant sources of employment through 1990, although their percent share in total employment should decline somewhat during this period (i.e., from 50.0% to 46.6%). Primarily under the influence of coal development, minerals extraction is projected to increase its relative share in total employment between 1978 and 1980 (i.e., from 17.8% to 19.0%). While declining in its relative share of total employment after peaking in 1980, mining employment is projected to show continued moderate growth in absolute terms through the end of the decade. Construction employment should peak in 1985 due to the projected construction of a gasification plant in Converse County, then decline in both relative and absolute terms through 1990. Among the other sectors of the regional economy, agriculture should continue to decline in relative importance as a source of employment through 1990, from 3.3% in 1978 to 2.5% by 1990. Manufacturing is projected to decline from 5.4% to 5.0% of total employment during the period under study. Railroad employment would increase slightly, from 0.4% to 0.9% of regional employment. Government employment should show considerable absolute and relative increases (from 14.9% to 18.7% of total employment).

Projected regional employment would be mirrored to varying degrees among the individual counties, but the percentages of workers employed in the various sectors under the low-level scenario should not differ substantially from those shown in Chapter 4.

The above discussion actually understates the importance of coal mining as a source of regional employment, since many jobs in the construction, and business and consumer services sectors are indirectly dependent on purchases by the coal companies and their employees.

Table R8-15 displays estimates of direct and indirect coal-related employment by county, in terms of numbers of workers and as percentages of total county employment. For the region as a whole, coal-related employment is expected to increase as a percentage of total employment between 1978 and 1990, i.e., from 8.8% to 19.3%. In other words, approximately 52% of the total projected increase in employment between 1978 and 1990 would be attributable to coal.

Among individual counties, Campbell would be the most highly dependent upon coal-related employment (i.e., 1,909 or 26.8% of county employment in 1978, increasing to 4,621 or 39.2% by 1990). In addition, coal-related employment would be highly important in Crook County (rising from 342 or 23.2% of total employment in 1978, to 709 or 33.8% by 1990). Coal-related employment would account for more than 20% of total employment in two other counties by 1990: Converse (26.6% by 1990, compared with 9.1% in 1978), and Weston (22.0% in 1990, versus 11.6% in 1978). Coal-related employment is also projected to increase as a percentage of total employment in the other four counties. By 1990, the degree of dependency on coal-related employment in these four counties would range from a low of 1.0% (Niobrara) to a high of 13.0% (Natrona). Coal-related employment shown for Johnson, Niobrara, and Sheridan counties would consist mostly of indirect and induced employment rather than direct mine employment. (This assessment is limited to impacts of Campbell and Converse county coal mines and hence does not include employment of Sheridan County residents in Montana or Sheridan County coal mines.)

Income. Table R8-16 contains low-level scenario earnings projections for the eight-county region. Total earnings in the region would be expected to rise from $631.1

TABLE R8-14

EMPLOYMENT PROJECTIONS BY SECTOR
1978-1990
LOW-LEVEL SCENARIO

	1978		1980		1985		1990	
	No.	% Total	No.	% Total	No.	% Total	No.	% Total
Agriculture	1,669	(3.3)	1,685	(3.1)	1,698	(2.7)	1,698	(2.5)
Minerals Extraction	9,064	(17.8)	10,883	(19.9)	11,920	(18.8)	12,749	(19.0)
Construction	4,167	(8.2)	4,436	(8.1)	6,249	(9.9)	4,837	(7.2)
Manufacturing	2,764	(5.4)	2,867	(5.3)	3,101	(4.9)	3,337	(5.0)
Railroads	182	(0.4)	321	(0.6)	583	(0.9)	635	(0.9)
Business/ Consumer Services	25,408	(50.0)	26,288	(48.2)	29,370	(46.4)	31,308	(46.6)
Government/ Education	7,575	(14.9)	8,093	(14.8)	10,416	(16.4)	12,579	(18.7)
Military	22	*	22	*	22	*	22	*
Total**	50,851	100.0	54,586	100.0	63,359	100.0	67,165	100.0

Sources: University of Wyoming 1978.

* Less than 0.1%.
** Totals may not add to 100.0% due to rounding.

TABLE R8-15

PROJECTED COAL-RELATED EMPLOYMENT BY COUNTY
1978-1985
LOW-LEVEL SCENARIO

County	1978		1980		1985		1990	
	No. of Workers	As Percent of County Employment	No. of Workers	As Percent of County Employment	No. of Workers	As Percent of County Employment	No. of Workers	As Percent of County Employment
Campbell	1,909	(26.8)	2,814	(34.4)	3,884	(38.8)	4,621	(39.2)
Converse	354	(9.1)	498	(11.0)	2,623	(38.7)	1,621	(26.6)
Crook	342	(23.2)	480	(29.5)	1,137	(59.2)	709	(33.8)
Johnson	31	(1.6)	44	(2.2)	76	(3.6)	107	(4.7)
Natrona	1,300	(5.0)	1,793	(6.7)	3,025	(10.3)	4,258	(13.0)
Niobrara	3	(0.3)	4	(0.5)	6	(0.7)	9	(1.0)
Sheridan	262	(3.7)	367	(4.8)	630	(7.1)	892	(9.4)
Weston	278	(11.6)	530	(19.6)	652	(21.9)	707	(22.0)
Region	4,479	(8.8)	6,530	(12.0)	12,033	(18.9)	12,952	(19.3)

Source: University of Wyoming 1978.

Note: Employment includes direct, indirect, and induced.

* Railroad employment is included only in regional employment totals.

TABLE R8-16

PROJECTED EARNINGS BY SECTOR
(MILLIONS OF 1975 DOLLARS)
1978-1990
LOW-LEVEL SCENARIO

	1978		1980		1985		1990	
	Dollars	% Total	Dollars	% Total	Dollars	% Total	Dollars	% Total
Agriculture	15.3	(2.4)	17.7	(2.5)	18.8	(7.9)	19.9	(1.7)
Minerals Extraction	142.2	(22.5)	181.9	(25.2)	237.8	(24.5)	302.4	(25.2)
Construction	84.0	(13.3)	93.6	(13.0)	154.0	(15.9)	135.2	(11.3)
Manufacturing	41.4	(6.6)	44.4	(6.2)	52.8	(5.4)	62.5	(5.2)
Railroads	2.7	(0.4)	4.9	(0.7)	10.3	(1.1)	12.8	(1.1)
Business/ Consumer Services	265.6	(42.1)	287.6	(39.9)	361.8	(37.3)	464.0	(38.7)
Government/ Education	79.5	(12.6)	90.1	(12.5)	134.3	(13.8)	203.1	(16.9)
Military	0.4	(0.1)	0.4	(0.1)	0.5	(0.1)	0.6	(0.1)
Total*	631.1	(100.0)	720.6	(100.0)	960.0	(100.0)	1,200.5	(100.0)

Source: University of Wyoming 1978.

* Totals may not add to 100.0% due to rounding.

million in 1978 to $1,200.5 million in 1990, a total increase of 90.2% or 5.5% annually. (All figures are expressed in 1975 equivalent dollars.) It is anticipated that business and consumer services would remain the predominant source of earnings in the region as a whole through 1990, followed in second place by minerals extraction. However, business and consumer services is expected to decline from 42.1% of total regional earnings in 1978 to 38.7% in 1990, while minerals extraction should increase from 22.5% to 25.2% of total earnings between 1978 and 1990. Construction should continue as the third largest source of regional earnings at least through 1985 (when it should account for 15.9% of total earnings), then decline to 11.3% as planned energy construction projects are completed. By 1990, government/education would have replaced construction as the third largest source of regional earnings, contributing 16.9% of the total. Agriculture would continue to decline in relative importance, from 2.4% of regional earnings in 1978, to 1.7% in 1990. Manufacturing would also decline in relative importance as a source of regional earnings between 1978 and 1990, from 6.6% to 5.2%.

Trends in projected earnings on the individual county level would mirror these regionwide developments to varying degrees, but are not expected to differ substantially from those discussed in Chapter 4.

As an aid in assessing the overall importance of the coal industry to the regional economy, Table R8-17 presents estimates of earnings generated by coal-related activities under the low-level scenario. Coal-related activities are defined here not only as direct mining activities, but also indirect and induced activity generated by mine expenditures and miners' personal consumption expenditures.

On a regionwide basis, coal-related earnings are projected to increase from $65.5 million (10.4% of total earnings) in 1978 to $209.1 million (21.6% of total earnings) by 1985. Thereafter, between 1985 and 1990, coal-related earnings should continue to grow in absolute terms (i.e., to $223 million), but decline somewhat in relative terms to 18.6% of total regional earnings. (All dollar figures are expressed in 1975 dollars.)

The largest absolute share of projected coal-related earnings would be concentrated in Campbell County, which is expected to obtain $66.4 million or 40.6% of total county earnings from coal-related activities by 1985. In 1990, Campbell County would earn $81.7 million (36.2% of total earnings) from coal-related activities.

In 1985, Converse County would receive the largest relative share of total earnings from coal-related activities, $57.4 million or 47.0% of total county earnings. Between 1985 and 1990, coal-related earnings in Converse County would decline in both absolute and relative terms (to $31.1 million or 26.5% of county earnings). This decline would be largely the result of the completion of the construction of the coal gasification plant northeast of Douglas and subsequent major layoffs of construction workers.

Other counties which would receive a major share of their total earnings from coal-related sources include Crook (in which coal-related earnings should increase from 28.5% to 41.1% of total earnings between 1978 and 1985, before declining to 36.9% by 1990) and Weston. In the latter, coal-related earnings are expected to grow from 15.1% to 26.6% of total earnings by 1985, then decline slightly to 25.2% by 1990.

The four counties previously discussed would derive their coal-related earnings from a combination of direct mine earnings and indirect and induced earnings generated by mine and mine worker expenditures. Coal-related earnings in the remaining four counties (Johnson, Natrona, Niobrara, and Sheridan) would consist almost entirely of indirect and induced earnings. These counties would vary with regard to the coal-related share in total county earnings, from a negligible amount in Niobrara County to 9.7% of total earnings in Natrona County in 1990.

Local Services. The impact of projected low-level scenario population growth on local services would vary widely among individual communities, depending of their current service levels and capacity of facilities, as well as the rate and magnitude of expected population growth. However, for the most part, the impacts on local services would not alter measurably from the impacts described in Chapter 4. The only exception is Gillette, which would require 11 additional police officers under this scenario by 1990, compared with the 12 officers needed to meet the demands of the cumulative population under the probable level.

Housing. Table R8-18 shows projected growth of housing demand under the low-level scenario, compared with historical growth rates in the housing stock. In Gillette, the demand for single-family housing is expected to grow at a rate of 6.0% annually between 1977 and 1990. The demand for single-family housing in Douglas, Glenrock, and Moorcroft is projected to grow at average annual rates of 3.6%, 4.6%, and 8.6% respectively. In the other communities of the eight-county region, the projected increase in demand for single-family housing would be the same as described in Chapter 4. Based on comparisons with historical rates of growth in the local stock of single-family housing, the local housing market should be able to meet the additional demand through 1990. Other aspects of the local housing situation, notably the large number of households unable to afford single-family housing, as well as the obstacles to development of housing alternatives, are discussed in Chapter 4.

Education. The following section discusses projected school district enrollments for the eight-county region for the low-level scenario (see Table R8-19). Population enrollment projections differ significantly from the enrollment projections in Chapter 4 only in Gillette.

In the Gillette School District, current building capacity plus planned expansion would bring total district capacity to 6,921 pupils by 1982, which is sufficient to meet projected enrollment increases through 1985. However, by 1990 an additional 700 junior/senior high school spaces, plus 500 more elementary spaces would be needed. The district would also need to hire an additional 249 teachers by 1990 in order to maintain current pupil/teacher ratios.

TABLE R8-17

PROJECTED COAL-RELATED EARNINGS BY COUNTY
(MILLIONS OF 1975 DOLLARS)
1978-1985
LOW-LEVEL SCENARIO

County	1978		1980		1985		1990	
	Amount	As Percent of County Earnings	Amount	As Percent of County Earnings	Amount	As Percent of County Earnings	Amount	As Percent of County Earnings
Campbell	29.3	(31.2)	43.4	(37.3)	66.4	(40.6)	81.7	(36.2)
Converse	5.1	(10.0)	6.6	(10.4)	57.4	(47.0)	31.1	(26.5)
Crook	5.3	(28.5)	7.7	(35.1)	12.3	(41.1)	14.9	(36.9)
Johnson	0.4	(1.7)	0.5	(1.9)	1.0	(3.2)	1.4	(3.6)
Natrona	15.2	(4.8)	21.9	(6.4)	41.9	(9.7)	55.0	(9.7)
Niobrara	*	-	*	-	*	-	*	-
Sheridan	3.0	(3.7)	4.4	(4.6)	8.6	(6.7)	11.4	(7.2)
Weston	4.5	(15.1)	9.2	(25.1)	12.2	(26.6)	14.7	(25.2)
Region**	65.5	(10.4)	98.6	(13.7)	209.1	(21.6)	223.0	(18.6)

Source: University of Wyoming 1978.
Note: Earnings include direct, indirect, and induced.
* Negligible
** Rail earnings are included only in the regional earnings total.

TABLE R8-18

PROJECTED HOUSING DEMAND
1978-1990
LOW-LEVEL SCENARIO

Community/ Housing Type	1977 Housing Stock	Average Annual Growth Rate of Housing Stock 1970-77*	Additional Demand for Housing Units 1977-1990 Total No. of Units	Average Annual Growth of Housing Stock Required 1977-90*
Gillette				
Single-family	1,623	5.2%	1,857	6.0%
Multi-unit	680	6.3%	486	4.2%
Mobile	1,542	13.3%	1,492	5.3%
Total all types	3,845	8.1%	3,835	5.5%
Douglas				
Single-family	1,232	6.5%	721	3.6%
Multi-unit	207	0.7%	350	7.9%
Mobile	349	24.8%	1,206	12.2%
Total all types	1,788	8.2%	2,277	6.5%
Glenrock				
Single-family	439	NA	318	4.3%
Multi-unit	63	NA	162	10.3%
Mobile	159	NA	569	12.4%
Total all types	661	3.7%	1,049	7.6%
Moorcroft				
Single-family	147	NA	285	8.6%
Multi-unit	0	NA	63	0
Mobile	150	NA	230	7.4%
Total all types	297	NA	578	8.7%

TABLE R8-18
(cont'd)
PROJECTED HOUSING DEMAND
1978-1990
LOW-LEVEL SCENARIO

Community/ Housing Type	1977 Housing Stock	Average Annual Growth Rate of Housing Stock 1970-77*	Additional Demand for Housing Units 1977-1990 Total No. of Units	Average Annual Growth of Housing Stock Required 1977-90*
Buffalo				
Single-family	1,398	4.8%	55	0.3%
Multi-unit	93	-12.0%	44	3.0%
Mobile	130	11.4%	164	6.5%
Total all types	1,621	3.3%	263	1.2%
Casper				
Single-family	12,034	2.3%	1,840	1.1%
Multi-unit	3,580	3.0%	963	1.8%
Mobile	655	18.1%	3,142	14.5%
Total all types	16,269	2.8%	5,945	2.4%
Lusk				
Single-family	NA	NA	17	NA
Multi-unit	NA	NA	22	NA
Mobile	NA	NA	93	NA
Total all types	720	0.2%	132	1.3%
Sheridan				
Single-family	3,993	2.1%	600	1.1%
Multi-unit	477	-3.0%	421	5.0%
Mobile	780	45.7%	1,563	8.8%
Total all types	5,250	2.4%	2,687	3.2%
Newcastle				
Single-family	950	0.4%	369	2.6%
Multi-unit	246	6.1%	81	2.2%
Mobile	172	9.9%	242	7.0%
Total all types	1,368	1.6%	592	2.8%

Note: See Table R4-16 for derivation of projections.
* Compounded annually
NA = Not available

TABLE R8-19

PROJECTED CUMULATIVE SCHOOL DISTRICT ENROLLMENTS
1980-1990
LOW-LEVEL SCENARIO

	1980				1985				1990			
	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total
Campbell												
Gillette	2,880	1,555	1,053	5,089	3,790	1,520	1,386	6,697	4,592	1,841	1,680	8,114
Converse												
Douglas	1,259	482	409	2,152	2,397	918	783	4,098	2,156	825	704	3,685
Glenrock	509	240	216	965	709	335	302	1,346	719	340	306	1,366
Crook												
Sundance	714	359	334	1,407	826	415	388	1,629	894	450	419	1,763
Johnson												
Buffalo	763	334	324	1,420	802	351	340	1,493	847	371	360	1,578
Natrona												
Casper	7,320	3,307	3,505	14,132	8,296	3,748	3,972	16,016	9,430	4,260	4,515	18,205
Niobrara												
Lusk	304	155	161	621	312	160	166	639	321	164	171	656
Sheridan												
Ranchester	361	188	189	738	362	189	189	740	361	191	189	742
Sheridan	2,009	961	872	3,842	2,507	1,199	1,080	4,794	3,102	1,483	1,385	5,930
Clearmont	89	21	34	144	89	22	34	145	89	22	35	146
Weston												
Newcastle	713	324	353	1,390	792	360	391	1,543	859	390	426	1,675
Upton	245	109	104	458	272	121	116	509	291	129	124	544

Source: University of Wyoming 1978.

Health Care. Chapter 2 discussed the shortage of health care personnel characteristic of most northeastern Wyoming communities. Unless these communities have significantly greater success in attracting and holding new medical specialists, this shortage would be aggravated by any population increase.

Table R8-20 projects the number of additional physicians, registered nurses, and dentists required to provide recommended levels of health care to the local population through 1990. On the local as well as the regional level, these requirements do not differ measurably from those described in Chapter 4.

Present hospital facilities as well as additional facilities either under construction or planned should be sufficient to meet the projected demands of the low-level population through 1985. By 1990, however, the region would need 193 additional hospital beds (compared with the requirement for 196 beds under the probable level of development). These needs could be met through new hospital construction, or if possible, by increasing the presently low average utilization rate of existing bed facilities.

Retail Trade. Projections of retail sales on a regional or individual county basis are approximately the same as those described in Chapter 4.

Local Finances. Douglas, Glenrock, and Moorcroft, municipalities which would face potential operating deficits under the probable level of development, would experience the same operating shortfalls under the low-level scenario. Municipal governments' capital cost deficits are likewise approximately the same under the probable level of development and the low-level scenario. (See Chapter 4.)

HIGH-LEVEL SCENARIO

The high-level scenario presents a cumulative analysis of a level of coal development higher than the probable level which has been described and analyzed in the first seven chapters of this statement. The high level represents a possible level of coal production which could supply the demand indicated by industry expressions of interest which have been evidenced by past leasing, preference right lease applications, and submission of proposals in areas of interest for coal development.

Any future federal actions related to potential coal production would require additional assessment of environmental impacts. The requirements of the Surface Mining Control and Reclamation Act, the 43 CFR 3041 and 30 CFR 211 regulations, and other applicable state and federal laws and regulations would apply to potential coal development (see Chapter 3).

In Campbell and Converse counties, there are approximately 24,000 acres of federal coal lands under lease for which mining and reclamation plans have not yet been submitted. Federal coal lease reserves and preliminary industry proposals and plans indicate the potential for six new mining projects as well as future expansion of existing mines. The federal coal leases for which mining and reclamation plans have not been submitted are shown on Map 1, Appendix A. Development potentials on these leases are summarized in Table R8-21.

There are approximately 91,000 acres of federal coal lands under preference right lease application. All preference right lease applicants in the Eastern Powder River Basin were required to make an initial showing of commercial quantities (development potential) by July 1977. Based on the initial showings, the potential exists for ten new mining projects, extension of three existing mines, and a commercial in situ coal gasification project by 1990. It should be noted that the in situ gasification process is still in an experimental stage, and that several parties are conducting or will conduct small scale testing of the process. Timing and scale of commercial in situ gasification project will be somewhat dependent on results of this testing. Preference right lease applications are shown on Map 1, Appendix A, and development potential is summarized in Table R8-21.

Additional interest in potential coal development has been expressed through industry proposals on approximately 32,000 acres of federal, state, and private coal lands. The potential exists for eight new mines and extension of two additional mines. Involved lands are shown on Map 1, Appendix A. Development potential for areas of interest is summarized in Table R8-21.

The high-level scenario presents a cumulative assessment of impacts from new coal development in the region. This new coal development includes the site-specific action (Buckskin) as well as the potential coal development described above.

The high-level scenario also presents a cumulative assessment of potential coal development, the site-specific action, continuation of fourteen mines which are operating or pending approval, coal-related development (one power plant, one gasification plant, and completion of a new major rail line), and other major regional development (oil and gas, uranium, transmission line construction, and municipal development).

Tables R8-22, R8-23, R8-24, and R8-25 define, derive, and summarize acreage and water requirements for the high-level scenario. The assumptions and guidelines used in developing the analysis of the high-level scenario include those in Chapter 1 plus the assumptions which follow. Where data were unavailable, conversion factors were developed for use in the high-level scenario using averages of data used in Chapter 1.

Assumptions

As stated in Chapter 1, Assumptions and Analysis Guidelines.

Companies would mine coal and accomplish reclamation as stated in preliminary proposals and/or initial showings in a manner consistent with state and federal law.

Time frames for potential coal development assume that there will be no new federal coal leasing prior to 1980. Thus the following represents a possible development sequence:

Year 0—Lease issuance.

TABLE R8-20

PROJECTED HEALTH CARE PERSONNEL REQUIREMENTS
LOW-LEVEL SCENARIO

	1977 Physicians	Physicians Recommended Levels*			1977 Registered Nurses	Registered Nurses Recommended Level**			1977 Dentists	Dentists Recommended Level***		
		1980	1985	1990		1980	1985	1990		1980	1985	1990
Campbell	9	18	24	29	53	63	84	101	4	11	15	18
Converse	6	11	19	18	29	38	67	62	2	7	12	11
Crook	2	5	6	7	11	19	22	24	1	3	4	4
Johnson	4	7	7	8	30	24	25	27	2	4	5	5
Natrona	80	59	67	76	383	208	236	268	34	37	42	48
Niobrara	2	3	3	3	12	11	11	11	1	2	2	2
Sheridan	26	24	27	32	154	83	96	111	16	15	17	20
Weston	3	7	8	9	26	26	29	31	2	5	5	6
Region	132	135	162	181	698	473	570	636	62	84	101	113

Source: Wyoming Department of Health and Social Services 1977; personal communication, Larry Bertilson, State Health Planning Manager 1978.

* Based on recommended standard of 1,000 persons per physician.
** Based on recommended standard of 285 persons per registered nurse.
*** Based on recommended standard of 1,600 persons per dentist.

TABLE R8-21

HIGH LEVEL OF COAL DEVELOPMENT (PROPOSED, EXISTING, AND POTENTIAL COAL MINING) BY 1990

Projects	Annual Coal Production (millions of tons per year)			
	1978	1980	1985	1990
Site-Specific Action				
Buckskin	0	2.0	4.0	4.0
Low-Level Scenario Mines				
14 Mines	49.5	107.0	164.6	169.3
Potential Development on Existing Federal Coal Leases				
(6 new mines)	0	0	38.0	52.0
Potential Development on Preference Right Coal Lease Applications				
(10 new mines, extension of 3 existing mines, and 1 in situ coal gasification project*)	0	0	35.0	45.0
Potential Development on Areas of Interest				
(8 new mines, extension of 2 additional mines)	0	0	28.0	59.0
TOTAL	49.5	109.0	269.6	329.3

TABLE R8-21
(cont'd)
HIGH LEVEL OF COAL DEVELOPMENT (PROPOSED, EXISTING, AND POTENTIAL COAL MINING) BY 1990

	EMPLOYMENT						Estimated Number of Unit Trains per Year*****		
	1980		1985		1990				
Projects	Const.	Perm.	Const.	Perm.	Const.	Perm	1980	1985	1990
Site-Specific Action									
Buckskin	25	125	0	133	0	125	200	400	400
Low-Level Scenario Mines									
14 mines	520	2,608	5	3,764	0	3,766	10,175	14,835	15,305
Potential Development on Existing Federal Coal Leases									
(6 new mines)	0	0	400	1,500	0	1,900	0	3,800	5,200
Potential Development on Preference Right Coal Lease Applications									
(10 new mines, extension of 3 existing mines, and 1 in situ coal gasification project)	0	0	700	1,400	0	2,100	0	3,500	4,500
Potential Development on Areas of Interest									
(8 new mines, extension of 2 additional mines)	0	0	225	661	200	1,151	0	2,800	5,900
TOTALS	545	2,733	1,330	7,458	200	9,050	10,375	25,335	31,305

38 mines

TABLE R8-21
(cont'd)
HIGH LEVEL OF COAL DEVELOPMENT (PROPOSED, EXISTING, AND POTENTIAL COAL MINING) BY 1990

	ACREAGE				
Projects	Total Permit Acres**	Federal Coal Acres	Total Surface to be Disturbed by 1990***	Average Acres Disturbed per year****	Acres Reclaimed by 1990
Site-Specific Action					
Buckskin	1,760	600	377	50	14
Low-Level Scenario Mines					
14 mines	84,505	69,063	18,729	1,809	12,652
Potential Development on Existing Federal Coal Leases					
(6 new mines)	32,000	28,000	5,000	500	1,200
Potential Development on Preference Right Coal Lease Applications					
(10 new mines, extension of 3 existing mines, and 1 in situ coal gasification project)	120,000	100,000	14,000	1,700	4,000
Potential Development on Areas of Interest					
(8 new mines, extension of 2 additional mines)	32,000	26,200	5,700	697	2,400
TOTALS	270,265	223,863	43,806 -19279 24,527	4,756	20,266

TABLE R8-21
(cont'd)
HIGH LEVEL OF COAL DEVELOPMENT (PROPOSED, EXISTING, AND POTENTIAL COAL MINING)
BY 1990

Projects	MARKET AREA
Site-Specific Action Buckskin	Oklahoma
Low-Level Scenario Mines (14 mines)	Mine mouth electric generation, gasification, also plains, Gulf, Ohio Valley, midwest, and southern states
Potential Development on Existing Federal Coal Leases (6 new mines)	unknown
Potential Development on Preference Right Coal Lease Applications (10 new mines, extension of 3 existing mines, and 1 in situ coal gasification project)	unknown
Potential Development on Areas of Interest (8 new mines, extension of 2 additional mines)	Largely unknown although the midwest, south central, and plains states are anticipated

* In situ gasification production not on table. Average gas production is estimated to reach 150 million cubic feet per day after 1990.

** All acreage within the area of operations for the mine.

*** Only acreage disturbed by mining operations. By 1990, 9,679 additional acres would be disturbed by mine facilities.

**** Annual average rate for new surface disturbance by mining activity.

***** One unit train equals 100 cars, each car having a capacity of 100 tons of coal. Does not include return traffic. Coal exported from the region would be shipped south or southeast.

TABLE R8-22

CUMULATIVE DEVELOPMENT FOR THE REGION
HIGH LEVEL OF DEVELOPMENT

	1978	1980	1985	1990
Coal Mining				
Number of Coal Mines*	11	20	36	38
Number of In Situ Gasification Projects	0	0	1	1
Coal Mine Support Facilities:				
Miles of Rail Spurs	41	90	164	178
Miles of Telephone Lines	34	55	120	123
Miles of Access Roads	11	30	62	65
Miles of Conveyor System	0	7	13	13
Miles of Power Lines	76	110	157	170
Coal-Related Development				
Number of Power Plants**	2	2	2	2
Number of Gasification Plants	0	0	1***	1
Miles of Railroad Line				
Main Line (common-carrier)	26	113	113	113
Private	0	0	40	40
Uranium				
Cumulative Number of Uranium Mines	3	4	6	7
Cumulative Number of Uranium Mills	2	3	4	4
Oil and Gas				
Area of Activity (acres)	4,800	4,880	5,110	5,250
Other				
Miles of New 230-kv Transmission Lines	0	0	87	87
Population increase(1,000's)****	0	4	28	36

Note: 1978 base, and based on industry plans and indicated trends.

* Counts East Gillette and Kerr McGee #16 individually.
** Wyodak and Dave Johnston.
*** Under construction.
**** Centaur Management Consultants, Inc. 1978. Based on University of Wyoming (1978) projection model for Campbell and Converse counties. Population increases represent increased population over 1978 base population (25,500).

TABLE R8-23

SUMMARY OF CUMULATIVE ACREAGES DISTURBED AND RECLAIMED BY COAL MINING ACTIVITY HIGH LEVEL OF DEVELOPMENT

		Cumulative Acreage			
		1978	1980	1985	1990
Surface Mine Operations		2,700	5,983	23,384	43,806
Power Lines		455	660	940	1,020
Rail Spurs		861	1,890	3,440	3,740
Access Roads		132	360	740	780
Conveyor Systems		0	70	130	130
Mine Structures		1,139	2,200	3,470	3,750
Relocations		36	190	190	190
Totals:	Acres Disturbed	5,323	11,353	32,294	53,416
	Acres Reclaimed	1,301	3,495	11,687	20,266
	Difference	4,022	7,858	20,607	33,150

TABLE R8-23a

COMPARISON OF CUMULATIVE AGREAGES FOR EXISTING AND NEW (PROPOSED AND POTENTIAL) COAL MINING ACTIVITY

		1978	1980	1985	1990
Existing Coal Mining Activity*					
	Acres Disturbed	5,323	8,119	16,084	22,136
	Acres Reclaimed	1,301	3,495	9,887	12,652
	Difference	4,022	4,624	6,197	9,484
New Coal Mining Activity**					
	Acres Disturbed	0	3,234	16,210	31,280
	Acres Reclaimed	0	0	1,800	7,614
	Difference	0	3,234	14,410	23,666

* From Table R8-3.

** Calculated by subtracting existing coal mining activity acreages from total acreage difference in the table above (R8-23).

TABLE R8-24

CUMULATIVE ACREAGE DISTURBED AND RECLAIMED BY REGIONAL DEVELOPMENT ACTIVITIES
HIGH LEVEL OF DEVELOPMENT

	1978	1980	1985	1990
Acreage Disturbed				
Coal Mining Activity*				
Existing	5,323	8,119	16,084	22,136
New	0	3,234	16,210	31,280
				53,416
Power Plants	2,000	2,000	2,000	2,000
Coal Gasification	0	0	1,500	1,500
Railroad Line				
Main Line	546	2,373	2,373	2,373
Private	0	0	840	840
Uranium	4,000	5,000	9,500	13,000
Oil and Gas	4,800	4,880	5,110	5,250
Sand, Gravel, Scoria	200	200	620	1,280
230-kv Transmission Line	0	0	1,566	1,566
Population**	0	400	2,800	3,600
TOTAL	16,869	26,206	58,603	84,825
Acreage Reclaimed				
Coal Mining Activity*				
Existing	1,301	3,495	9,887	12,652
New	0	0	1,800	7,614
Other Activities	400	1,400	3,550	6,300
TOTAL	1,701	4,895	15,228	26,566
Difference	15,168	21,311	43,375	58,259

Note: For average acreage requirements, refer to Table R1-4.
* From Table R8-23a.
** Acreage required for population increase over 1978 base municipal acreage.

TABLE R8-25

INCREASED WATER USAGE FOR THE REGION
HIGH LEVEL OF DEVELOPMENT

Type of Use	Annual Water Requirements (Acre-feet)								
	1975	1978	Inc.*	1980	Inc.*	1985	Inc.*	1990	Inc.*
Coal Mines	170	1,000	830	2,500	2,330	5,000	4,830	6,200	6,030
Irrigation	10,000	10,000	0	10,000	0	10,000	0	10,000	0
Municipal**	3,990	6,650	2,660	7,980	3,990	16,530	12,540	18,810	14,820
Oil Fields (water-flood)	12,000	12,000	0	12,000	0	12,000	0	12,000	0
Uranium Mines	80	240	160	320	240	480	400	560	480
Uranium Mill	500	2,000	1,500	3,500	3,000	7,500	7,000	9,500	9,000
Power Plants***	7,500	7,630	130	7,630	130	7,630	130	7,630	130
Gasification Plants	N/A	N/A	N/A	N/A	N/A	15,000	15,000	19,000	19,000
Stockwater and Domestic	10,000	10,000	0	10,000	0	10,000	0	10,000	0
TOTAL	44,240	49,520	5,280	53,930	9,690	84,140	39,900	93,700	49,460
Sewage**** (Based on 70% of municipal use)	2,800	4,600	1,800	5,586	2,786	11,571	8,771	13,167	10,367

Note: Based on Table R1-7 with projected high-level increases.
* Increase over base year (1975).
** Includes need for projected population increase in the region.
*** Includes Wyodak air-cooled and Dave Johnston water-cooled plants.
**** Not a part of cumulative total.
N/A = Not applicable.

Year 1—Mining and reclamation plan approval; begin construction.

Year 2—Construction continues.

Year 3—Complete construction; initial production (one half of full production).

Year 4—Full production.

Year 5—Full production continues.

Conversion Factors

Preliminary proposals and initial showings were used to develop figures for potential coal development in the high-level scenario. Where information was lacking, the conversion factors listed below were used. These conversion factors are based on averages of known mining plans and operations in the region.

1. Average acreage disturbed per year per million tons of coal mined equals 35.
2. Average acreage disturbed for rights-of-way and mine facilities equals 200 per coal mine.
3. Average mine life is 30 years.
4. Ninety percent of coal reserves are recoverable by surface mining.
5. Employment: construction—100 employees per mine; operations—30 employees per million tons of annual production.
6. Market calculations in unit trains and direction: east—43%; southeast—57%.

Impact Analysis

The impacts of the high-level scenario are analyzed at two levels: (1) the impacts of new (proposed and potential) coal development in the region, and (2) the cumulative impacts of all development in the region under the high-level scenario. This analysis focuses on impacts which differ significantly from those discussed in Chapter 4; therefore, the reader is directed to that chapter for additional detail on the general character of impacts.

Air Quality

Emissions and Modeling Procedures. The high-level scenario emission sources include, in addition to the low level sources, one proposed mine (the Buckskin Mine), and the potential development of additional mines.

Some of the potential mines provided very little information concerning mining procedures; therefore emissions were calculated using a method described in the Technical Report for Chapter 8, on file at the Bureau of Land Management, Casper District Office. The locations of the additional high-level scenario developments are shown on Figure R8-10. The emissions for each of the mines are listed in Table R8-26. The emissions from urban areas for the high-level scenario are shown in Table R8-27.

Highway traffic is expected to increase in parts of the region by 1990. Increased commuter traffic may increase TSP, NO_2, and carbon monoxide (CO) concentrations along highway corridors for a few hours each day. The traffic, however, is not expected to cause any regional impact on air quality.

A complete lack of data on the design and operations schedule of the in situ gasification plant precluded any modeling attempt.

The same dispersion modeling procedures used for the probable level analysis in Chapter 4 were used for the high-level scenario.

Proposed and Potential Development Alone. Concentrations referred to in this section are the contributions from the proposed and possible coal developments to pollutant levels. These contributions do not include baseline levels or contributions from other activities. Since most of the fugitive dust generated by mining operations would consist of relatively large diameter particles, most particulate deposition would occur within a few miles of the individual mines.

In 1980, only the site-specific action (Buckskin Mine) and one possible mine (14) (see Figure R8-10) are predicted to be producing coal. Increased TSP concentrations would not exceed 1 $\mu g/m^3$ except at the center of mining activities.

By 1985, possible development would include 26 mines, and by 1990, 29 mines. Figures R8-11 and R8-12 show predicted increases in annual TSP concentrations for 1985 and 1990. The major impact would occur in the area near Gillette. In this area, increases to the annual TSP concentrations would reach 10 $\mu g/m^3$ by 1990. The maximum increase to the 24-hour concentration should be approximately 34 $\mu g/m^3$.

None of the concentrations resulting from the proposed or possible coal development alone would violate the Wyoming TSP standard.

Interactions of the Proposed Coal Development and Other Activites. Concentrations mentioned in this section refer to the total concentrations (including baseline concentrations) due to the entire high-level scenario.

The high level of development would affect air quality over a large area and would cause higher concentrations of pollutants than the low level or probable level of development, except for 1980. In 1980, concentrations would be almost identical to the low-level scenario since additional development for the high-level scenario would be small and would have very little impact. See Figure R8-1 for TSP concentrations in 1980.

In 1985 and 1990, the maximum TSP concentrations would occur in the Gillette area. The interaction of Gillette's emissions with those of mine 7 (see Figure R8-10) would cause annual TSP concentrations of 45 $\mu g/m^3$ in 1985 and of about 65 $\mu g/m^3$ in 1990. Possible development mines would contribute 10 $\mu g/m^3$ to both concentrations. Hence, in 1990, Wyoming's annual standard of 60 $\mu g/m^3$ is predicted to be exceeded in the area where the emissions from Gillette and mine 7 interact. The maximum 24-hour concentration in this area for 1985 and 1990 would be 154 $\mu g/m^3$ and 227 $\mu g/m^3$ respectively.

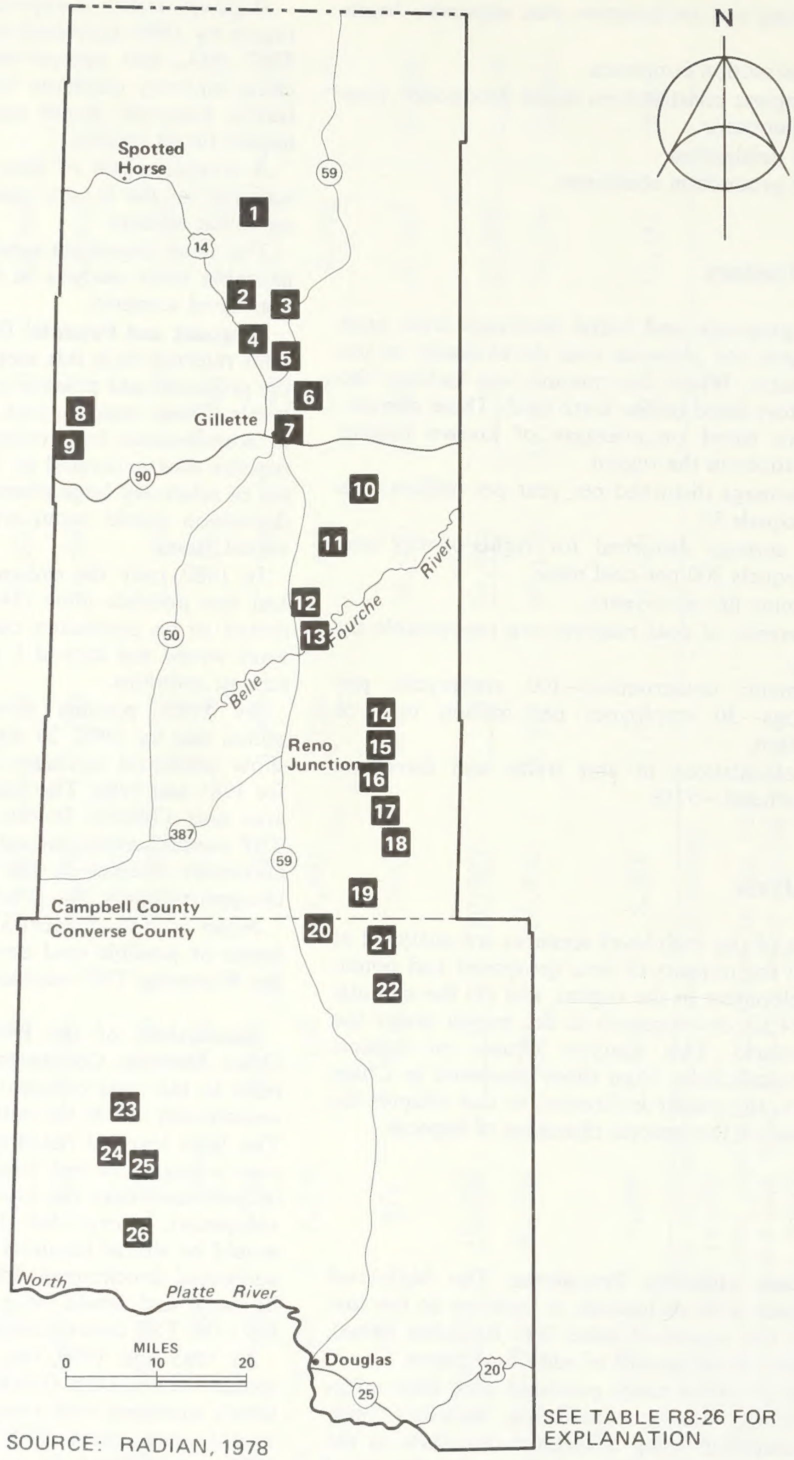


Figure R8-10

LOCATION OF PROPOSED FEDERAL ACTION AND POSSIBLE COAL DEVELOPMENTS

TABLE R8-26

PARTICULATE EMISSIONS (TONS/YEAR) FROM PROPOSED AND POSSIBLE DEVELOPMENTS

Map Number	Description of Activity	1980	1985	1990
1	New surface mine		2,778	1,507
2	New surface mine		6,227	6,227
3	New surface mine		1,137	2,628
4	Site-specific action (Buckskin)	762	1,175	1,275
4a	Possible Extension to 4	762	1,175	1,275
5	New surface mine		157	361
6	New surface mine		931	1,628
7	New surface mine		2,121	3,457
8	New surface mine		4,917	4,917
9	In situ gasification plant			
10	New surface mine		2,066	5,333
11	Possible mine extension		4,289	4,520
12	New surface mine		928	1,628
13	New surface mine**			
14	New surface mine	745	1,190	2,416
15-a	New surface mine		1,624	2,121
15-b	New surface mine		1,146	2,121
15-c	New surface mine		700	2,121
15-d	New surface mine			1,624
15-e	New surface mine			1,146
16	Possible mine extension		2,754	3,149
17	Possible mine extension		4,793	3,744
18	Possible mine extension		4,793	3,744
19	New surface mine		781	752
20	New surface mine		3,862	4,712
21	New surface mine		1,117	2,077
22	New surface mine		507	1,734
23	New surface mine		1,226	3,916
24	New underground mine			266
25	New surface mine		182	256
26	New underground surface mine		923	923

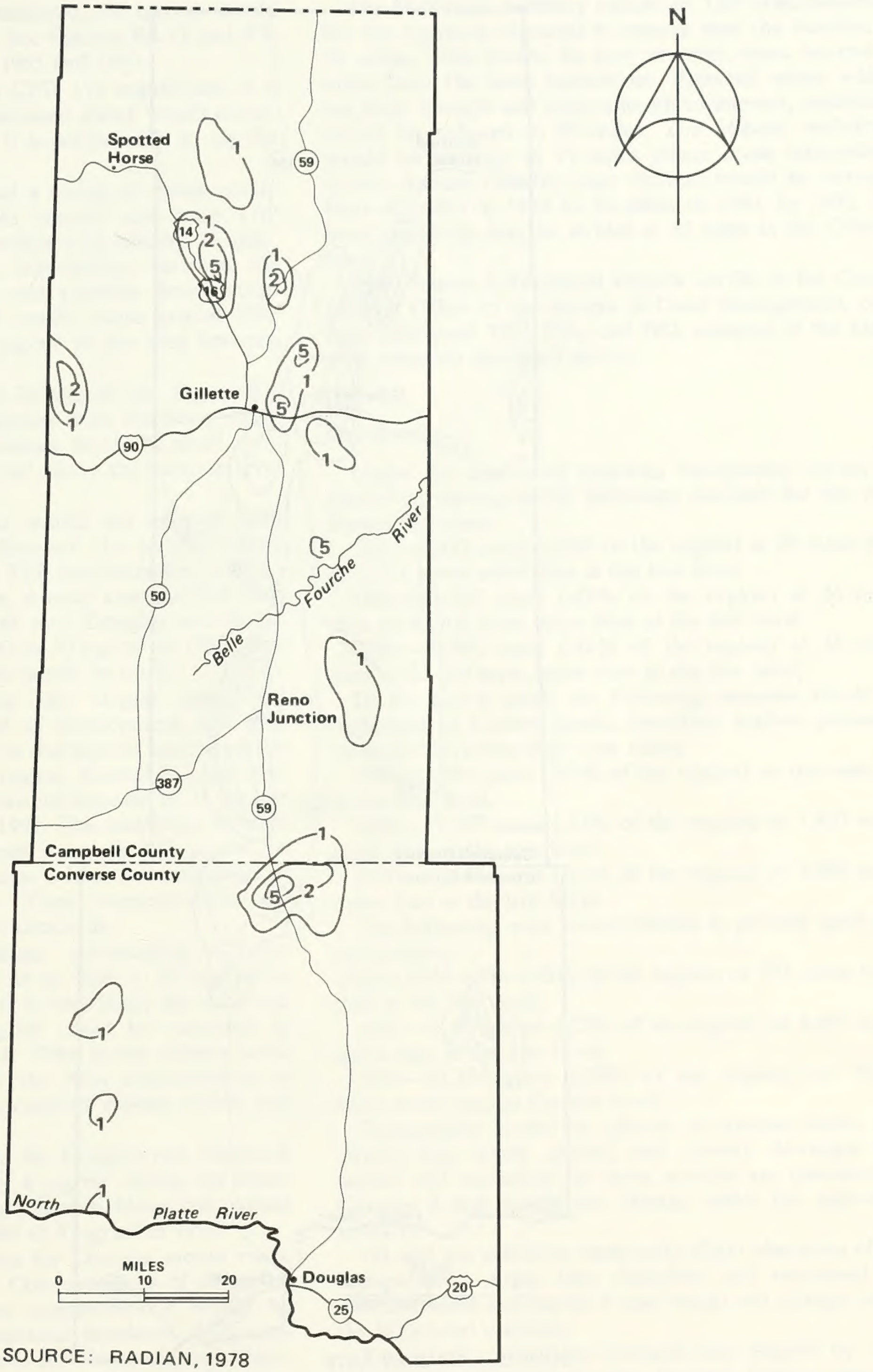
* See Figure R8-10.

** Very small project - production will be minimal.

TABLE R8-27

EMISSIONS OF PARTICULATES, SO_x, AND NO_x FROM TOWNS (TONS/YEAR)
HIGH-LEVEL SCENARIO

Town	Pollutant	1980	1985	1990
Gillette	Particulates	53	70	75
	SO_x	56	74	80
	NO_x	303	401	431
Moorcroft	Particulates	20	33	39
	SO_x	17	28	33
	NO_x	99	165	196
Glenrock	Particulates	22	32	33
	SO_x	17	25	26
	NO_x	117	175	182
Douglas	Particulates	36	61	60
	SO_x	29	49	48
	NO_x	200	334	329
Casper	Particulates	172	178	182
	SO_x	189	196	200
	NO_x	555	573	660



SOURCE: RADIAN, 1978

Figure R8-11

INCREASE OF TSP CONCENTRATIONS (μg/m³) DUE TO THE PROPOSED AND POTENTIAL COAL DEVELOPMENT ALONE FOR 1985

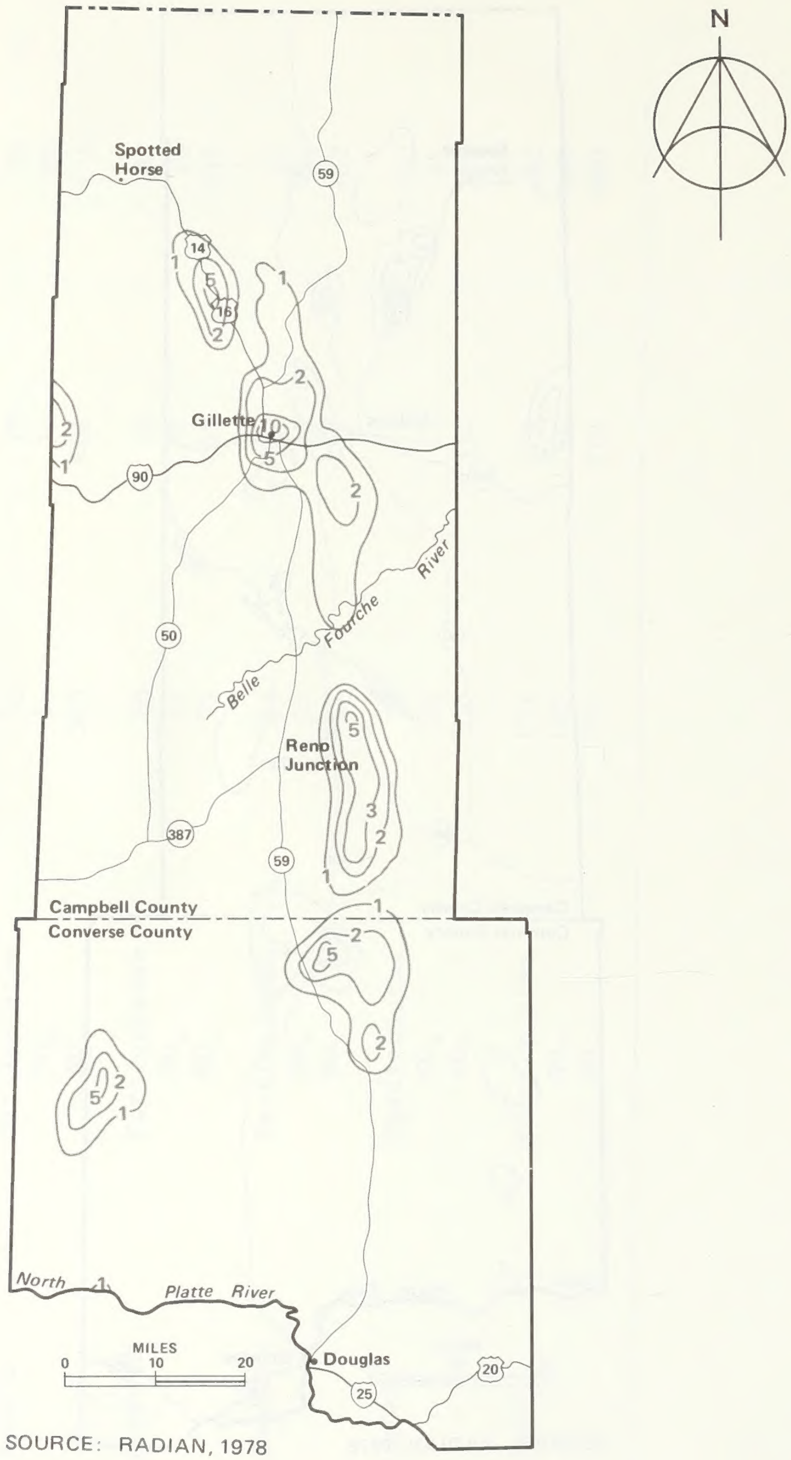


Figure R8-12
INCREASE OF TSP CONCENTRATIONS (μg/m^3) DUE TO THE PROPOSED AND POTENTIAL COAL DEVELOPMENT ALONE FOR 1990

Thus, the Wyoming 24-hour standard, 150 $\mu g/m^3$, would be violated in 1985 and 1990. See Figures R8-13 and R8-14 for TSP concentrations in 1985 and 1990.

With application of the 43 CFR 118 regulations, it is unlikely that the violations discussed above would occur. However, without modeling, it is not possible to say for certain.

Emissions from Gillette and a string of mines north-northwest of the town would interact and cause TSP concentrations of 30 $\mu g/m^3$ within a 2½-mile by 25-mile strip. Southeast of Gillette, interactions between the emissions of existing mines and possible development mine 12 (see Figure R8-10) would cause annual TSP concentrations to rise to 35 $\mu g/m^3$ in the area between the mines.

In Converse County, mines 23 and 26 (see Figure R8-10) would interact with the plume from the Dave Johnston Power Plant. The interactions would be small, raising concentrations 3 to 6 $\mu g/m^3$ above the baseline level of 24 $\mu g/m^3$.

The emissions from mines would not interact with Moorcroft, Douglas, and Glenrock. In addition there would be little change of the TSP concentration in Glenrock for the three study years. Annual average TSP concentrations around Moorcroft and Douglas would increase from 26 $\mu g/m^3$ in 1980 to 30 $\mu g/m^3$ in 1990. The area affected by these changes would be small.

Gillette would experience the largest population growth due to the high-level of development, and as a result, it would be subjected to the highest concentration of gaseous pollutants in the region. Annual SO_2 concentrations of 8 $\mu g/m^3$ in 1980 would increase to 23 $\mu g/m^3$ in 1985 and to 33 $\mu g/m^3$ in 1990. The maximum 24-hour SO_2 concentration is expected to reach 112 $\mu g/m^3$ in Gillette by 1990. The maximum 3-hour concentration in 1990 would be 185 $\mu g/m^3$. These concentrations are below Wyoming and national standards.

Annual NO_2 concentrations surrounding Gillette would increase from 40 $\mu g/m^3$ in 1980 to 70 $\mu g/m^3$ in 1985 and 90 $\mu g/m^3$ in 1990. It is very likely the state and federal standard of 100 $\mu g/m^3$ could be exceeded in downtown Gillette in 1985 or 1990. In the Gillette area, approximately 30 $\mu g/m^3$ of the NO_2 concentration in 1990 would be due to the proposed federal action and possible coal development.

Annual SO_2 concentrations for Douglas and Glenrock should remain approximately 8 $\mu g/m^3$ during the study period. Annual SO_2 concentrations in Moorcroft would increase from 6 $\mu g/m^3$ in 1985 to 8 $\mu g/m^3$ in 1990.

Annual NO_2 concentrations for Douglas would reach 30 $\mu g/m^3$ in 1985 and 1990. Concentrations of 65 $\mu g/m^3$ may occur in 1990. These concentrations would be below the Wyoming and national standards. NO_2 concentrations would remain low for Glenrock and Moorcroft, at approximately 20 $\mu g/m^3$ for 1985 and 1990.

Regional SO_2 concentrations for 1980 would be essentially the same as that shown on Figure R8-4. The remaining SO_2 and NO_2 annual concentrations are shown on Figures R8-15 through R8-19. The maximum short-term concentrations are listed for the towns in Table R8-28.

The horizontal visibility related to TSP concentrations for the region is expected to remain near the baseline of 54 miles. This would be true in most cases beyond 8 miles from the mine boundaries. Between mines which are large enough and close enough to interact, visibilities would be reduced to 44 miles. The 24-hour visibilities would be reduced to 17 miles where these interactions occur. Annual visibility near Gillette would be reduced from 40 miles in 1980 to 28 miles in 1990. In 1990, 24-hour visibilities may be as low as 10 miles in the Gillette area.

The Chapter 8 Technical Report, on file at the Casper District Office of the Bureau of Land Management, contains additional TSP, SO_2, and NO_2 analyses of the high-level scenario discussed above.

Topography

Under the high-level scenario, topography would be altered by mining in the following amounts for the time frames indicated.

1980—5,983 acres (.12% of the region) at 20 mine sites or 1,271 acres more than at the low level.

1985—23,383 acres (.47% of the region) at 36 mine sites or 10,706 acres more than at the low level.

1990—40,998 acres (.82% of the region) at 38 mine sites or 22,269 acres more than at the low level.

Of the above acres, the following amounts would be reclaimed to a more gentle, smoother surface generally 10 to 40 feet lower than now exists.

1980—3,495 acres (.07% of the region) or the same as at the low level.

1985—11,687 acres (.23% of the region) or 1,800 acres more than at the low level.

1990—15,656 acres (.31% of the region) or 3,004 acres more than at the low level.

The following area would remain in pit and spoil pile topography.

1980—1,488 acres (.03% of the region) or 271 acres more than at the low level.

1985—11,697 acres (.23% of the region) or 8,907 acres more than at the low level.

1990—25,356 acres (.50% of the region) or 19,279 acres more than at the low level.

Topography would be altered at uranium mines and quarry sites (sand, gravel, and scoria). Acreages disturbed and reclaimed by these acvities are discussed in Chapter 4 and would not change under the high-level scenario.

Oil and gas activities cause only slight alteration of the topogararaphy. Areas thus disturbed and reclaimed are also discussed in Chapter 4 and would not change under the high-level scenario.

Topography would be changed only slightly by coal-related development at mine support facility sites (an average of 200 acres per mine). The main impact of these activities would be at cut and fill sites to maintain grade along access roads and railroads. Acres disturbed by roads and railroads under the high-level scenario would be 4,623 acres in 1980 (867 more than at the low level); 7,393 acres in 1985 (2,797 more than at the low level);

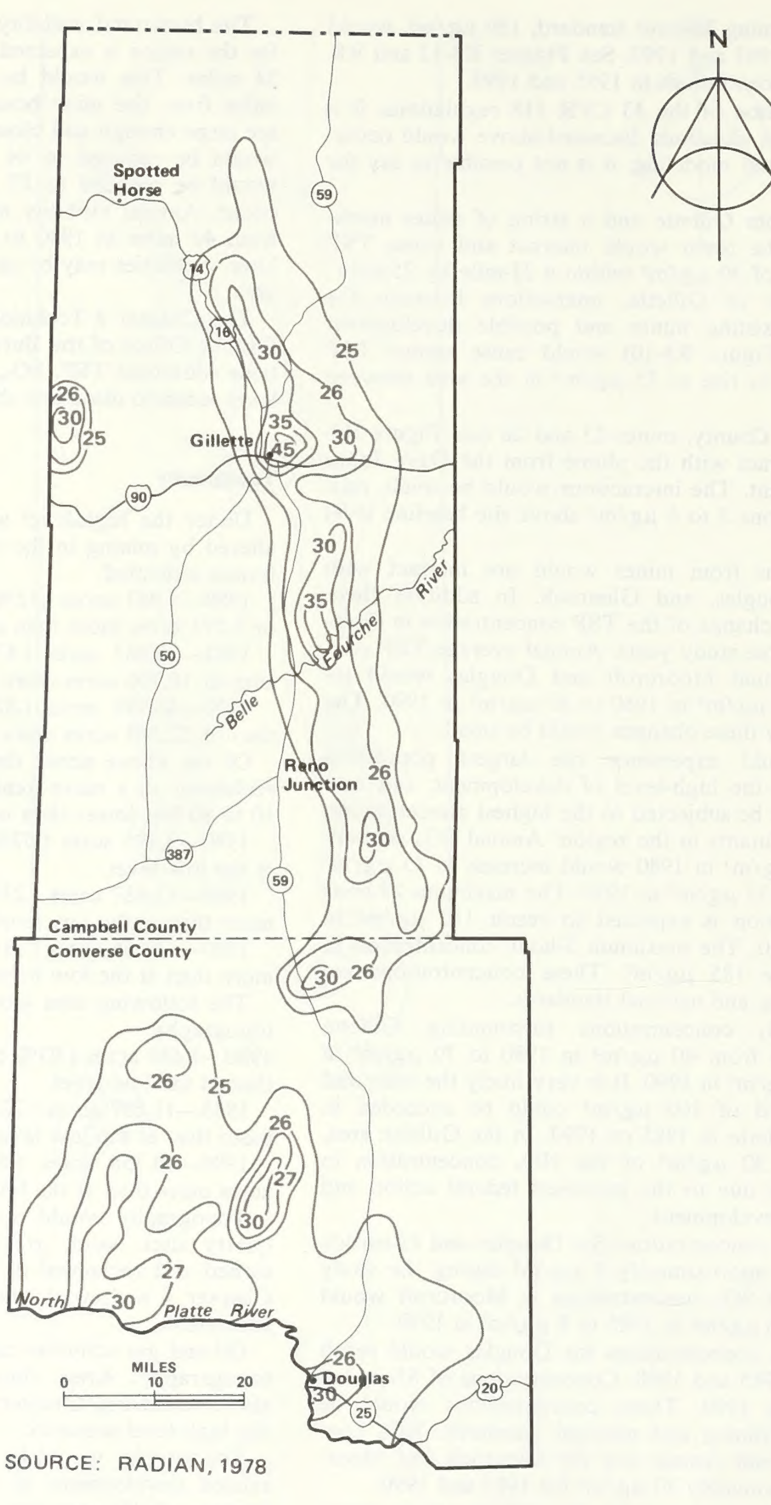
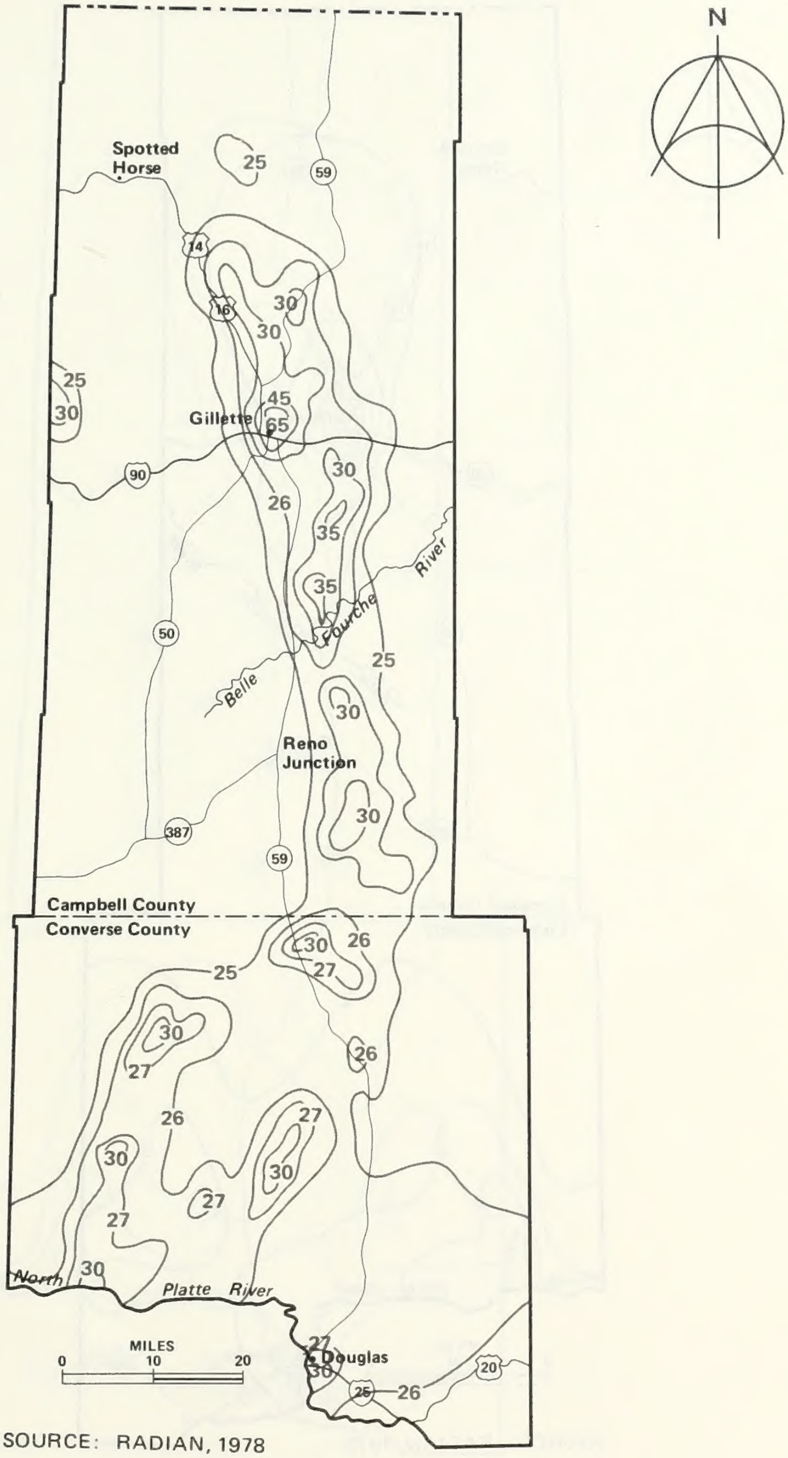
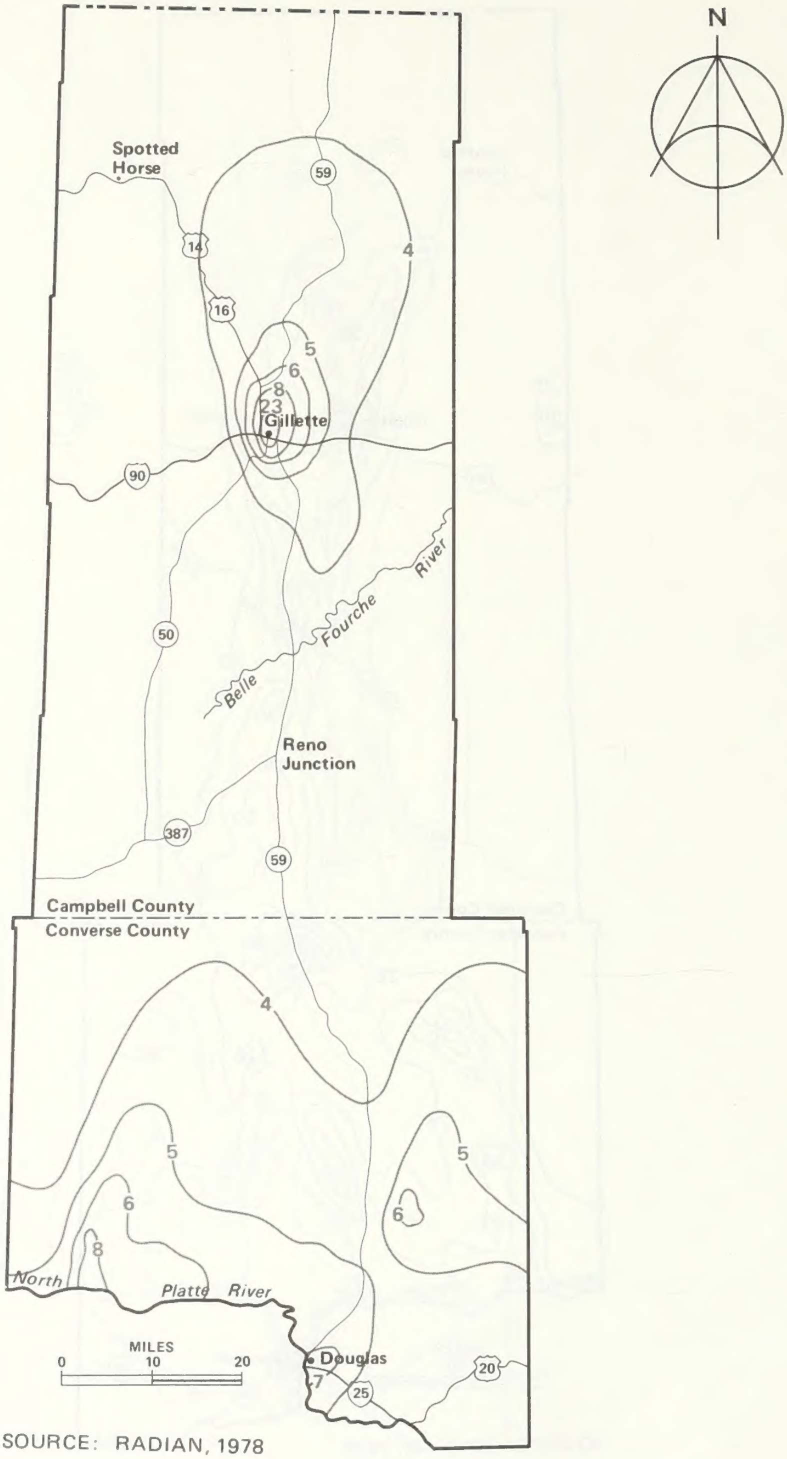


Figure R8-13
ANNUAL TSP CONCENTRATIONS ($\mu g/m^3$) FOR THE HIGH LEVEL SCENARIO FOR 1985



SOURCE: RADIAN, 1978

Figure R8-14
ANNUAL TSP CONCENTRATIONS ($\mu g/m^3$)
FOR THE HIGH LEVEL SCENARIO FOR 1990



SOURCE: RADIAN, 1978

Figure R8-15
ANNUAL SO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE HIGH LEVEL SCENARIO FOR 1985

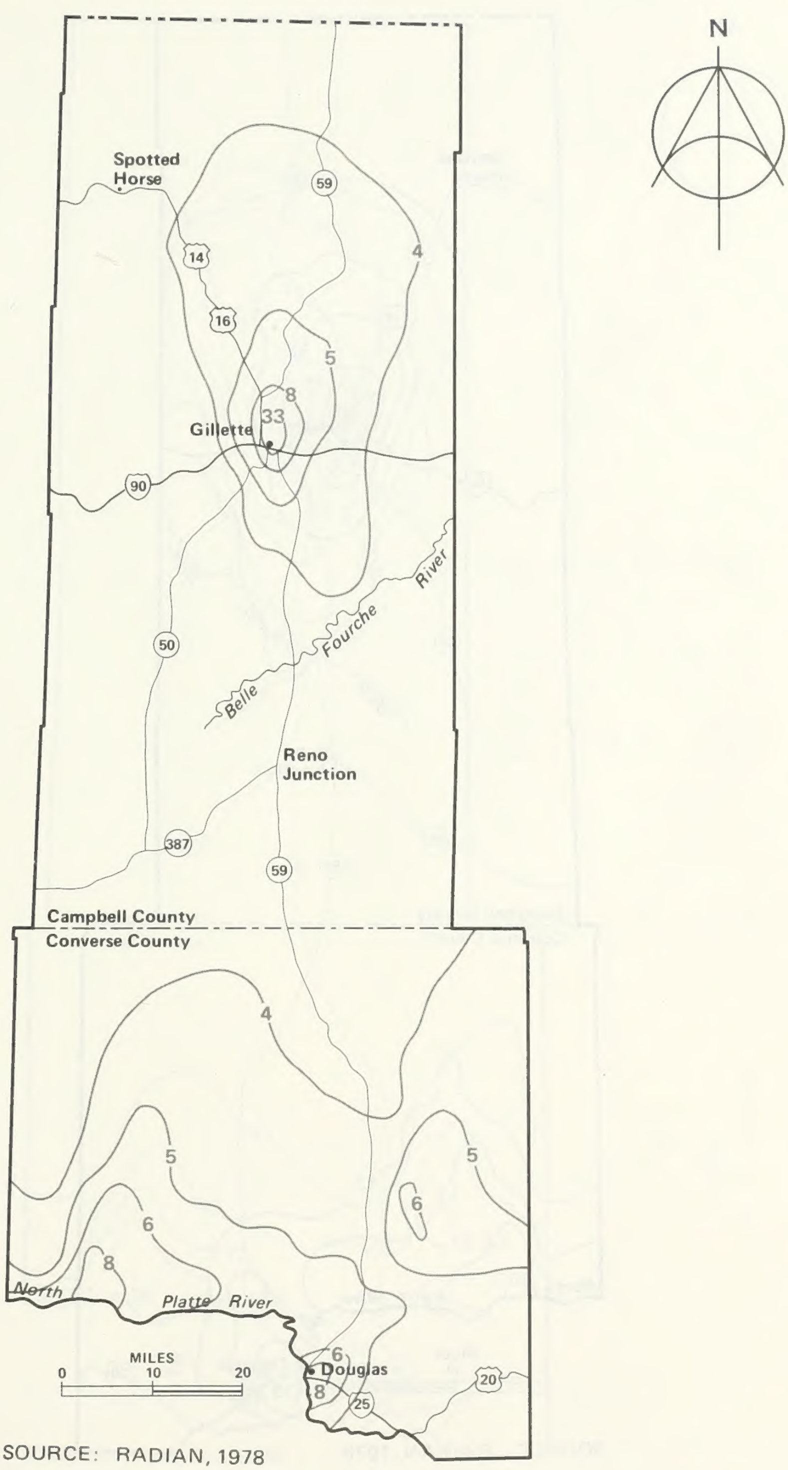
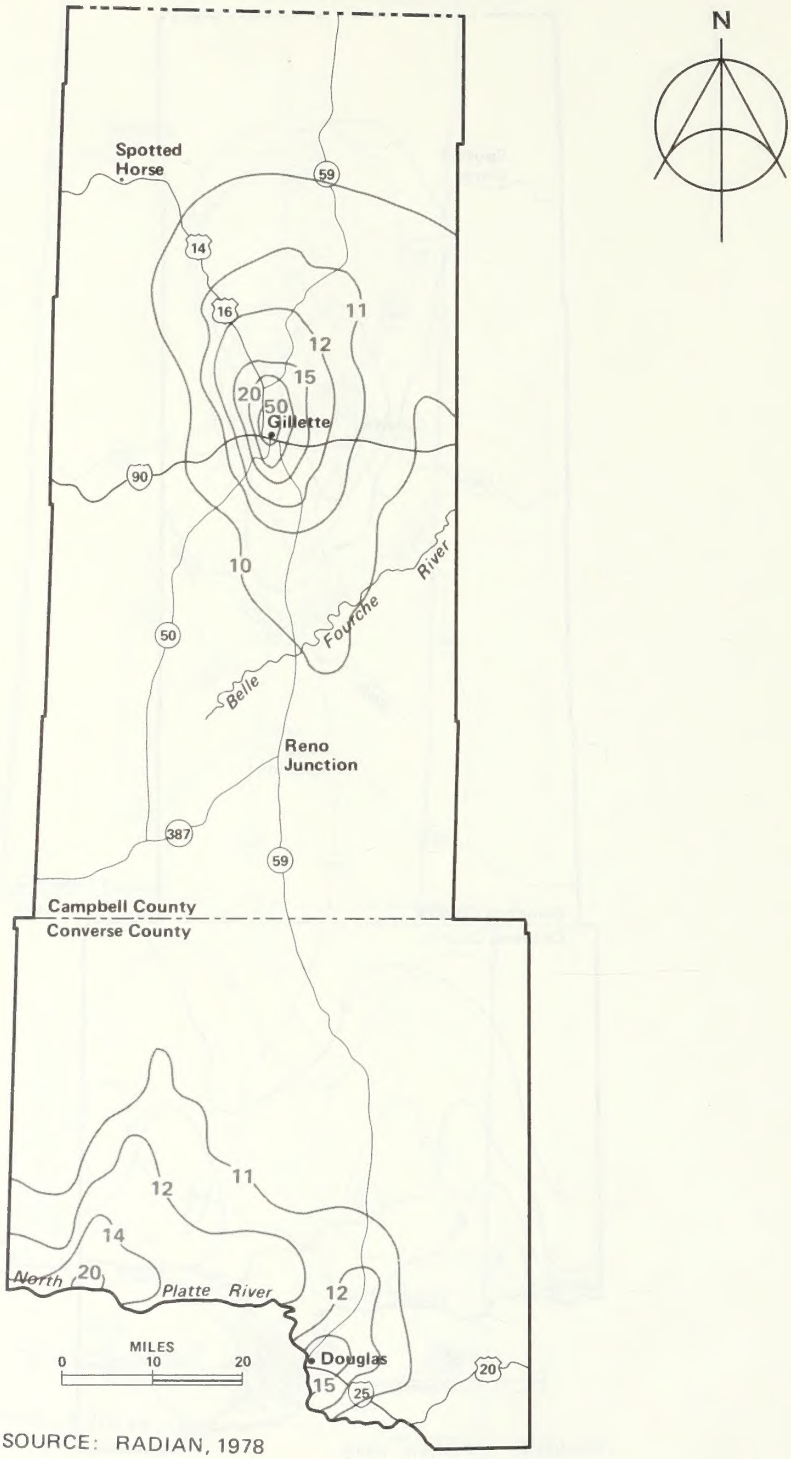
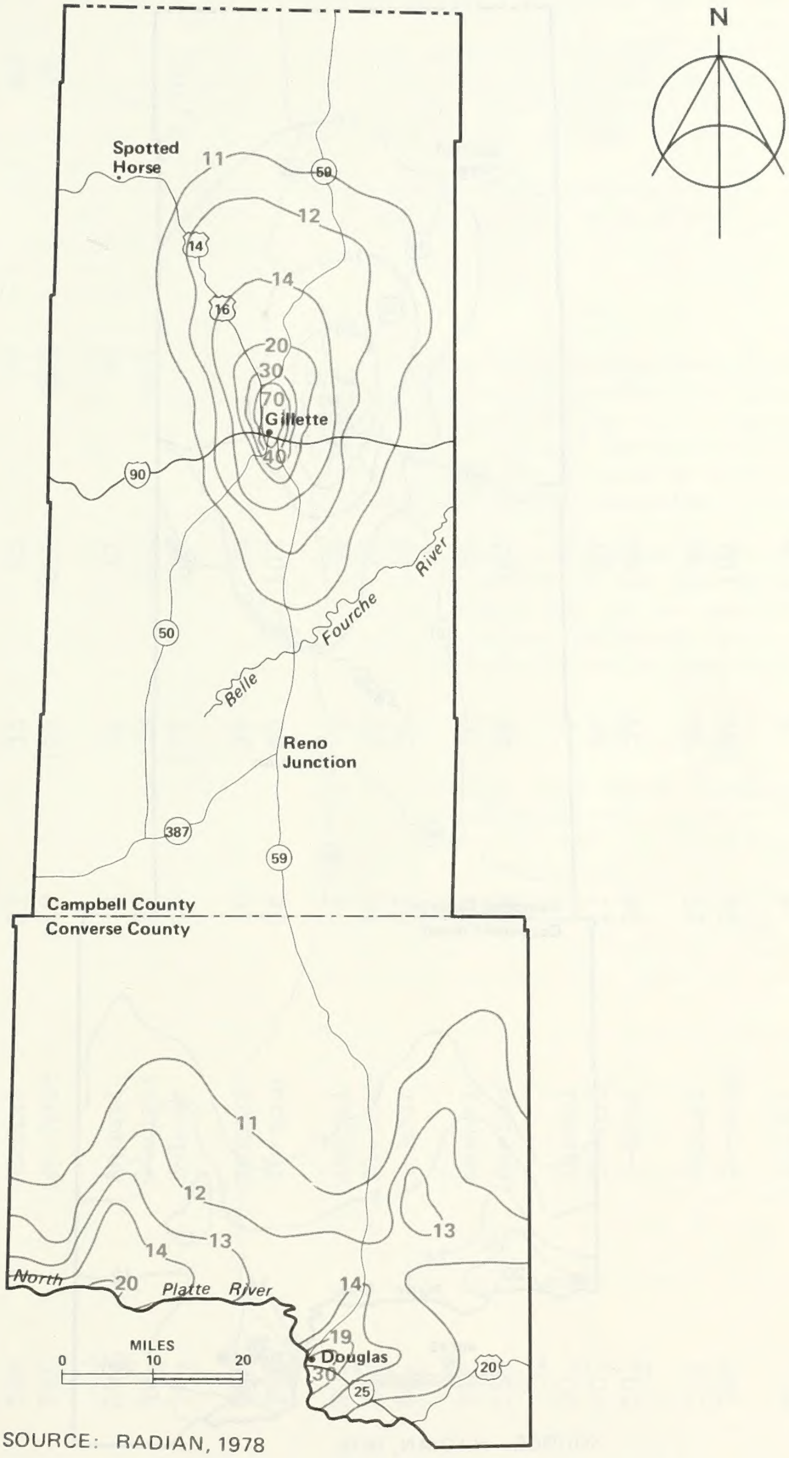


Figure R8-16
ANNUAL SO_2 CONCENTRATIONS ($\mu g/m^3$)
FOR THE HIGH LEVEL SCENARIO FOR 1990



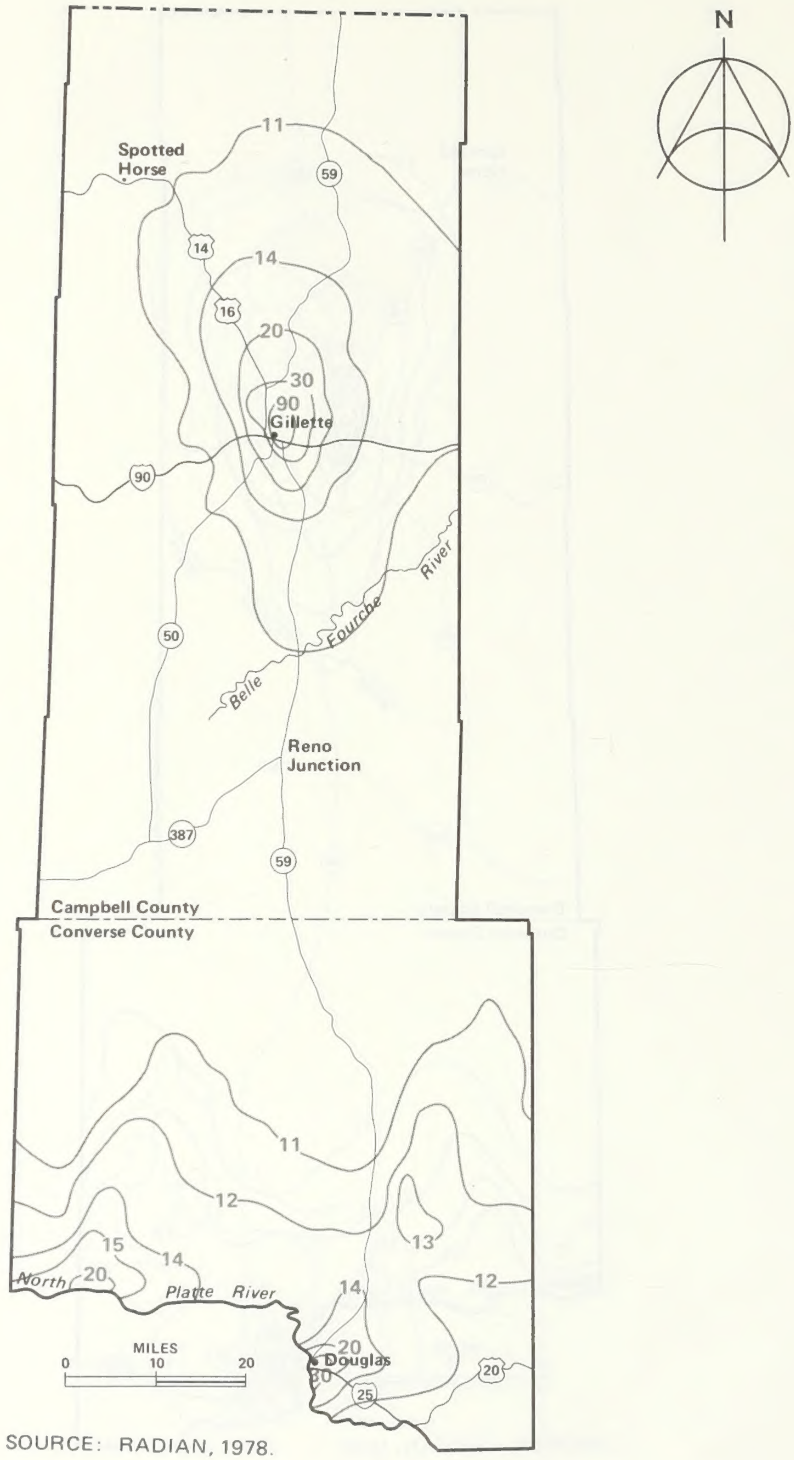
SOURCE: RADIAN, 1978

Figure R8-17
ANNUAL NO_2 CONCENTRATIONS ($\mu g/m^3$)
FOR THE HIGH LEVEL SCENARIO FOR 1980



SOURCE: RADIAN, 1978

Figure R8-18
ANNUAL NO_2 CONCENTRATIONS ($\mu g/m^3$)
FOR THE HIGH LEVEL SCENARIO FOR 1985



SOURCE: RADIAN, 1978.

Figure R8-19
ANNUAL NO_2 CONCENTRATIONS ($\mu g/m^3$) FOR THE HIGH LEVEL SCENARIO FOR 1990

TABLE R8-28

ANNUAL AND MAXIMUM SHORT-TERM CONCENTRATIONS ($\mu g/m^3$) PREDICTED AROUND TOWNS IN THE REGION FOR THE HIGH-LEVEL SCENARIO WITH THE NATIONAL AND WYOMING AIR QUALITY STANDARDS ($\mu g/m^3$)

Town	Pollutant	Averaging Period	1980	1985	1990	National Standards Primary	National Standards Secondary	Wyoming Standard
Gillette	TSP	Annual	35	35	65	75	60	60
	TSP	24-hour	119	154	221	260	150	150
	SO_2	Annual	8	23	33	80	-	60
	SO_2	24-hour	27	78	112	365	-	260
	SO_2	3-hour	45	129	185	-	1,300	1,300
Moorcroft	TSP	Annual	26	26	30			
	TSP	24-hour	88	88	102			
	SO_2	Annual	4	6	8			
	SO_2	24-hour	14	20	27			
	SO_2	3-hour	22	34	45			
Douglas	TSP	Annual	26	30	30			
	TSP	24-hour	88	88	102			
	SO_2	Annual	5	7	8			
	SO_2	24-hour	17	24	27			
	SO_2	3-hour	28	39	45			
Glenrock	TSP	Annual	27	30	30			
	TSP	24-hour	92	102	102			
	SO_2	Annual	8	8	8			
	SO_2	24-hour	27	27	27			
	SO_2	3-hour	45	45	45			

Note: Standards for averaging times less than one year are not to be exceeded more than once a year.

and 7,733 acres in 1990 (3,137 more than at the low level).

Disturbance would occur along 233 miles of access roads and railroads by 1980 (46 miles more than at the low level), along 379 miles by 1985 (144 more than the low level), and along 396 miles by 1990 (161 more than the low level).

Figures for total area disturbed by all regional development may be found in Table R8-24 for the high-level scenario.

Geology

Under the high-level scenario, loss of geologic record would be about 16,509,408 acre-feet at coal mines, or about double the low level of 8,984,438 acre-feet and the probable level of 9,075,000 acre-feet. The beneficial impact of exposure of otherwise inaccessible geologic data to scientific examination would be approximately doubled.

Paleontology. Under the high-level scenario, the potential fossil-bearing strata lost by 1990 would be nearly twice that lost under the low and probable levels. The beneficial impact of exposure of fossil material for scientific examination would also be nearly doubled.

Soils

Future population increases in the region would result in the removal of soil from several thousand acres by the year 1990 (see Table R8-24). This permanent loss of soil surface would result from the construction of housing and support facilities. Also, an increase in population would result in greater use of the region's soils for recreation, particularly off-road vehicle use. The amount of impact on soils that would result from recreation is unknown.

Major disturbance and alteration of soils as a result of mining would cause a reduction in soil productivity on the affected soils. Chapter 4 describes the various processes resulting in loss of soil productivity.

For a summary of cumulative acreages disturbed and reclaimed by new coal mining activity under the high level of development, refer to Table R8-23.

For a summary of cumulative acreages disturbed and reclaimed by all regional development activities under the high level of development, refer to Table R8-24.

Water Resources

Groundwater. The difference in impacts between the high and low level of development is a difference in scale rather than type of impacts. The impacts of additional mining of the Wyodak seam, or its northern equivalents in the region, would be the same as those previously described for the low and probable levels. The impact of a particular mine would depend on whether the mine is located in a recharge or discharge area and on the coal to overburden ratio.

If the coal that crops out along the breaks of the Powder River is mined in the future, the impact on groundwater in the coal, if the coal is saturated, would be similar to that which would occur north of Gillette at existing mines.

If new coal mines open on the west side of the Powder River structural basin in the southern part of the region, unlike the situation at the Dave Johnston Mine, saturated overburden and/or coal may be disturbed. Because the sandstone in the area is apparently more permeable than that to the north, the impacts, other than those on quality of water, would be similar to impacts of surface uranium mines in the area. Aside from radioactive material that may be present, the impact on quality of water would be the same as described for mines on the Wyodak seam.

The in situ gasification of coal is projected under the high level of development. While some water is required for the production of a high-quality gas, large quantities of water are detrimental to the in situ gasification process. If a coal is saturated, dewatering would be necessary with concomitant lowering of water levels in the adjoining coal. Toxic substances, phenols and cyanides, do enter the groundwater system by convective transport in both the vapor and solution phases of in situ gasification. Although toxic substances have been demonstrated to enter the groundwater, experiments in the field and laboratory by Lawrence Livermore Laboratories indicate that concentrations of toxic material return to the levels existing before gasification in a matter of months only 300 feet from the gasification site (personal communication, U.S. Geological Survey, Water Resources Division, Cheyenne 1978). This rapid decrease in toxic material is attributed to the sorptive properties of the coal.

Impacts of additional uranium mining, uranium mills, and coal gasification plants would be the same type as for the probable level. Table R8-25 shows projected water use under the high level of development. Increased use would probably be from groundwater.

Surface Water. The high level of mining activity in the region envisions a coal production about 110% greater than that of the most probable level. This would result in an almost continuous, crescent-shaped area of impact about 120 miles long stretching from just north of Glenrock, up through a point about 10 miles east of Reno Junction, to a point about 30 miles north of Gillette.

Some major impacts to the surface water resource are estimated in Table R8-29. Depressions and potholes caused by differential settlement in the reclaimed areas would increase infiltration and probably be beneficial on a short-term basis. On a long-term basis however, each depression could become a collector of water-transported, toxic materials which have leached from the reclaimed spoils. This could be especially true if the depression should contact the groundwater table.

Settlement of the area where larger streams traverse the reclaimed spoils would cause interception of the drainage upstream from the mine. Entrapment of streamflow from this drainage would depend on the areal extent and depth of settlement. Flow entering the depression would cause downcutting of the unmined stream

TABLE R8-29

IMPACTS OF HIGH LEVEL OF DEVELOPMENT ON SURFACE WATER RESOURCES

	VALUES AT HIGH LEVEL OF ACTIVITY*		VALUES AT PROBABLE LEVEL OF ACTIVITY*	
	1990	Long Term**	1990	Long Term**
Impacts***	All Activity	All Activity	All Activity	All Activity
Estimated depressions in square miles (40%, ± 10% will probably be fed by groundwater).	3.6 to 5.3	50 to 80****	2.5 to 3.6	9½ to 13
Estimated potential intercepted drainage area in square miles.	(None until end of final reclamation)	Up to 3,000	--	620 to 2,000
Estimated point-water sources:				
Ponds in acres (includes flowing wells, springs, playas, and lakes).	520	2,700	330	440
Wet streams in miles (perennial sections and wet-pothole sections).	78	400	50	80
Estimated potential sedimentation in acre-feet per year.	570	--	340	--

* Includes all mines, plants, and everything connected with them.

** After mining and reclamation is done.

*** The greatest impact in the region may occur to the quality of the water. There is not enough data available to quantify this degradation; see text for qualitative analysis.

**** Estimated water loss due to evaporation = 16,600 acre-feet/year or 23 cubic feet per second.

bed, downcutting and headcutting of tributaries, and increased sedimentation for a distance upstream from the mine. This would depend upon the amount of settlement. Flow entirely trapped in the depression would lose its sediment load; but that which overflows the depression would cause erosion and downcutting of the unmined channel downstream from the mine, with the same impacts just described for the stream portion entering the mine. This impact would probably be insignificant until after final reclamation since major streams are usually routed around the mine during mining.

Point-watering sources in the form of streamflow, ponds scattered intermittently through nonflowing stream beds, watering tanks supplied by wells, and stock ponds would be destroyed at the rate mining progresses.

Estimated potential sedimentation in Table R8-29 is that which could conceivably occur from spoil piles and other unreclaimed mine areas during years of heavy rainstorm activity. Much of this sediment would be trapped on the mine site but some would escape and add to the natural sediment stream load carried on downstream away from the mines. This impact should be eliminated with completion of reclamation.

See Table R8-25 for a tabulation of estimated water use in the region. Water use by all coal mining by 1990 is estimated to be about 3½% of all of the surface flow originating in the region (about 184,000 acre-feet per year), and to be about 13% of the total water currently used in the region (about 49,520 acre-feet per year).

The ash waste from the coal gasification plants and the finely ground wastes from the uranium mills would probably be a long-term source of water contamination by salts and heavy metals. The potentially most hazardous contamination may be the radioactivity escaping from the abandoned, covered tailings piles of uranium mills. These contain about 85% of the total radiation activity within the uranium ore being processed, which amounts to about 1,800 microcuries per pound (Clark and Kerr 1974). The main radioactive products emanating from the wastes include radon-222 gas escaping into the atmosphere and radium-226 (half-life 1,620 years) possibly escaping via water leaching into the ground and then out again in the form of seeps and springs, or via water traveling over the land after seeping from the piles. Radiation from radium-226 attacks the bones in animals. The maximum allowable concentration of radium-226 in water exposed to humans is about 3 picocuries per liter (pc/l). A range from 0.5 to 65 pc/l was found from about 60 samples from five effluents from uranium mines in the Colorado River Basin (Clark and Kerr 1974). Data are insufficient to quantify an estimated high level of impact for coal gasification and uranium industries.

See Chapter 4 for contrast of impacts and for discussion of possible degradation of water quality due to coal mining. This impact is expected to slowly decrease over a long period of time after mining is completed, until the impact is negligible. Data are insufficient to estimate this period of time.

Vegetation

Terrestrial. All coal development (existing, proposed, and potential) in the region would result in the removal of native vegetation and loss of productivity for varying periods of time on an estimated 11,353, 32,294, and 53,416 acres by 1980, 1985, and 1990 respectively. Approximately 1.0% of the region's surface acreage would be disturbed by coal activity by 1990. Additional disturbance of native vegetation would occur due to increased outdoor recreation (particularly off-road vehicle travel). Disturbed coal lands would be reclaimed by an estimated rate of 3,495 acres by 1980, 11,687 acres by 1985, and 20,266 acres by 1990. (Approximately 41% of the lands disturbed by coal activity by 1990 would be reclaimed.)

Total surface disturbance in the region resulting from coal-related and all other mineral activities would result in the removal of native vegetation on an estimated 26,206, 58,603, and 84,825 acres by 1980, 1985, and 1990. (Figures do not include outdoor recreation disturbances due to lack of data.) Coal mining would constitute about 43% (11,353 of 26,206 acres), 55% (32,294 of 58,603 acres), and 63% (53,416 of 84,825 acres) of the regional surface disturbance by 1980, 1985, and 1990 respectively.

Reclamation would be conducted generally on an ongoing basis. On a total disturbance basis, it is estimated that 4,895, 15,228, and 26,566 acres would be reclaimed by 1980, 1985, and 1990 respectively.

The removal of native vegetation and losses of vegetative production would affect numerous living and nonliving components of the environment. (See Chapter 4, Vegetation, and Chapter 8, Low-Level Scenario for reclamation problems and predictions of success). Under the high-level scenario, the impacts would increase by a factor of 56% over the low-level scenario and occur over a larger area.

Aquatic. Under the high-level scenario, the impacts to aquatic vegetation in ponds and streams would increase by a factor of five over the low-level scenario (see Table R8-29).

Endangered and/or Threatened Species. There is no record of any endangered or threatened plant species in the region; therefore no impact would be anticipated (see Chapter 2).

Fish and Wildlife

The combination of existing, proposed, and potential coal and other development would represent an increase in wildlife habitat destruction of 12.7% in 1980, 29.5% in 1985, and 38.6% in 1990, when compared to the low-level scenario. The increase in wildlife numbers directly lost would be proportional to the increase in habitat destroyed, as reflected in Table R8-30. See Chapter 4, Wildlife, for a detailed analysis of the effects of development on fish and wildlife habitat and populations.

It is not known what effect any of the potential coal development might have on endangered and/or threatened species. A survey would be conducted at each development site to determine whether such species are present or would be affected.

TABLE R8-30

SUMMARY OF ADVERSE IMPACTS TO WILDLIFE
HIGH-LEVEL SCENARIO

		Habitat Loss	Fishery (Estimated Individual Numbers)		Birds: Nongame	Birds: Game*	Birds: Raptors	Mammals: Nongame	Mammals: Game: Antelope	Mammals: Game: Deer
Proposed And Potential Coal Development	1980	3,234			16,493	659	18	12,289	105	15
	1985	16,210			82,671	3,305	91	61,598	527	76
	1990	31,280			159,528	6,378	176	188,864	1,017	147
Total of All Activities	1980	26,206			133,651	5,344	147	99,583	852	123
	1985	58,603	2 Streams 9½ Miles	2 Reservoirs 71 Total Acres	298,875	11,950	330	222,691	1,905	175
	1990	84,825			432,608	17,296	477	322,335	2,757	398

* Only doves

Cultural Resources

By 1990, cultural resource sites on an additional 31,000 acres would be threatened with destruction or alteration by new (proposed and potential) coal mining activity. Some may be threatened by their proximity to surface-disturbing activities. The significance of currently uninventoried cultural sites within unsurveyed tracts or buried sites anywhere on the mine sites cannot be determined at this time. Cultural resource inventories required before leasing or subsequent surface disturbance would reduce impacts to these resources.

Other activities affecting cultural resources in the region include uranium mining, coal conversion (power and gasification plants), oil and gas development, railroad, road, and utility construction, off-road vehicle use, vandalism, and private land development. The number of sites which may be disturbed or destroyed by these activities cannot be quantified at this time; however, compliance with Executive Order 11593 and Section 2(b) of the Historic Preservation Act would ensure mitigation of impacts to cultural resources which may be affected by much of the development activity.

Visual Resources

Changes already occurring in regional visual resources would be more than doubled by 1990 under the high-level scenario. Visual intrusions would be created by 45 uranium and coal mines (with attendant power lines, access roads, railroad spurs, processing equipment, service buildings, and open pits), 3 coal-conversion facilities, and 4 uranium mills. Of this total, development of new coal would account for 28 mines and 1 conversion plant. Housing, utility, and commercial expansion to accommodate increased population would cause further deterioration of the open country atmosphere of the region.

The amount of land disturbed for all regional development and unreclaimed by 1990 would be 58,259 acres, of which 23,666 acres (40%) would be attributable to proposed and projected coal development. Contrasts in form, color, line, and texture would be evident on these 58,259 acres, which amounts to 1% of the land surface in the region.

A reduction in air quality, and hence visibility, is expected in the region by 1990 due to increased levels of particulates and gaseous pollutants (see Air Quality).

Recreation Resources

The most significant effect of the high-level scenario on recreation resources would be to increase regional (Campbell and Converse counties) population, and hence recreation participation, 110% and 141% (over 1978 levels) by 1985 and 1990 respectively. In 1985 and 1990 respectively, populations would be 25% and 32% higher than the predicted populations under the low level of development. This increase would be attributable to the development of proposed and potential new coal. Increased recreation participation would further reduce the quality of the "primitive"recreation experience in the region and contribute to facility management problems and landowner-recreationist conflicts. A second effect of the high-level scenario would be to remove a total of 84,825 acres from the regional recreation base by 1990. Proposed and projected development of coal would account for 31,280 acres (37%) of this total. Total impacts on recreation discussed in Chapter 4 could be expected to more than double for the high-level scenario.

Agriculture

Livestock Grazing. All coal development (existing, proposed, and potential) in the region would result in the removal of vegetation and loss of productivity for varying periods of time on an estimated 11,353, 32,294, and 53,416 acres by 1980, 1985, and 1990 respectively. Cumulative loss of AUMs of grazing by benchmark periods would be 2,270, 6,458, and 10,683 respectively.

Total surface disturbance in the region resulting from coal-related and all other mineral activities would result in the removal of native vegetation on an estimated 26,206, 58,603, and 84,825 acres by 1980, 1985, and 1990. Cumulative loss of AUMs of grazing by these same time periods would be 5,241, 11,720, and 16,965 respectively.

Besides direct loss of livestock forage, other impacts associated with population increases, as discussed in Chapter 4, could occur. Under the high-level scenario, division of grazing areas, loss of stock watering facilities, and deposition of fugitive dust on vegetation (as discussed in the low-level scenario) would occur at an accelerated rate.

The loss of labor to higher paying industrial jobs and the rise in the costs of goods and commodities would be particularly detrimental impacts to the region's livestock industry under the high level of development (see Socioeconomic Conditions).

Farming. The development of energy-related minerals under the high-level scenario would result in the loss of crop-producing lands as shown in Table R8-31.

Prime and Unique Farmland. (See Chapter 4, Agriculture, Prime and Unique Farmland.)

Forest Resources

No impact to marketable forest resources would occur from the high level of development.

Mineral Resources

Under the high level of development, coal resources consumed would be the same as under the probable level through the early 1980s (see Chapter 4). In 1985, new coal resources consumed would be 105 million tons more than at the low level and 101 million tons more than at the probable level. A cumulative total of about 269.6 million tons would have been consumed instead of 164.6 at the low level or 168.6 at the probable level.

From 1986-1990, new coal resources consumed would be 525 million tons more than at the low level and 505

TABLE R8-31

SUMMARY OF PROJECTED LOSS OF AGRICULTURAL LAND AND PRODUCTION
HIGH-LEVEL SCENARIO

Year	Land Removed From Crop Production (Based on Total Acres Disturbed)		Annual Hay Production Lost (Tons)			Annual Dryland Wheat Lost (Bushels)	Other Cropland Lost (Acres)	
	(Acres) Dryland	(Acres) Irrigated*	Dryland .78 Tons/Acre	Irrigated 1.62 Tons/Acre	Total Tons	18.6 Bushels/Acre	Dryland	Irrigated
Coal Development 1980	236	68	95	41	180	1,541	24	16
All Activities 1980	550	159	222	194	415	3,585	60	40
Coal Development 1985	694	205	286	249	535	4,652	76	50
All Activities 1985	1,273	376	524	459	983	8,528	141	93
Coal Development 1990	1,170	338	479	418	898	7,622	129	83
All Activities 1990	1,833	541	754	660	1,415	12,280	203	134

million tons more than at the probable level. A cumulative total of about 2,500 million tons would have been consumed instead of about 1,835 at the low level or 1,855 at the probable level.

Consumption of other mineral resources such as uranium, sand, gravel, and scoria is discussed in Chapter 4, and there would be no significant change in those estimates under the high-level scenario.

Transportation Networks

Railroads. Projected increases in coal and noncoal freight train traffic flowing through or out of the Eastern Powder River Basin are described in Tables R8-32 and R8-33. Train traffic attributable to the mines operating under the high-level scenario represents a significant increase over low-level coal train traffic, amounting to 57 additional trains daily in 1985 and 88 additional trains daily in 1990.

At present, coal shipments from the Eastern Powder River Basin must be transported via the BN route through Gillette and on to Alliance, Nebraska. This track's current two-way maximum capacity of 40 to 65 trains per day must be upgraded by 1980 to accommodate the coal train traffic projected in Table R8-32. By 1985, the rail line currently under construction between Donkey Creek and Orin Junction, Wyoming would be available to relieve some of the pressure on the present BN line. However, coal train projections indicate that additional expansions would be needed along both routes to handle projected traffic flows.

Currently, virtually all of the Eastern Powder River Basin's coal exports have been destined to markets located northeast, east, or south of the area. Market destination data presented in Chapter 4 indicate that this pattern is expected to continue with subsequent coal shipments. Thus, the traffic projections for the high-level scenario assume that coal trains would continue to move eastward towards Nebraska. However, the restraint posed by the track capacity would preclude such an increase in traffic without major track expansion.

Impacts expected in communities along the BN routes are described below.

Northern Route. Sheridan and Gillette should not suffer additional adverse impacts beyond those described in Chapter 2. Nearly all of the projected additional coal train traffic would be routed along rail spurs which join the main BN line east of Gillette, at Donkey Creek.

In other communities along the northern route, the projected rail traffic increases would intensify the impacts described in Chapter 2. For example, in 1978, rail crossings in Newcastle are blocked from 1-1/4 to 2-1/4 hours daily by passing trains. Based on the train traffic projections in Table R8-32, at-grade railroad crossings would be blocked 4-1/2 to 7-1/2 hours daily in 1985 and 3-1/4 to 8-3/4 hours daily in 1990.

Traffic would be blocked for even longer periods in Alliance, where trains are slowed down by the switchyards. In Grand Island, vehicle access problems would be further compounded by the fact that Grand Island serves as the junction for the BN and Union Pacific railroads.

Southern Route. The opening of the rail line from Donkey Creek to Orin Junction in the early 1980s would expose communities not previously affected by coal train traffic (current traffic averages four regular freight trains daily) to heavy train traffic. Torrington has already taken steps to improve railroad crossings and install protection devices where needed. Plans do not include construction of any grade separations; however, if train traffic increases much beyond 22 trains per day (which it would, based on the train projections shown in Table R8-32), a grade separation over a major highway would be needed (personal communication, Keith Newman, Torrington Chamber of Commerce and John Lane, Wyoming State Highway Department 1978).

Approximately two-thirds of the coal train traffic passing through Torrington would continue south through Sidney, Nebraska to Sterling, Colorado. (The other third would flow east to Alliance.) Hence Sidney could expect significantly greater impacts from railroad traffic under the high-level scenario.

Other Transportation. The population of Campbell and Converse counties under the high level of development is projected to be 25% higher in 1985 and 32% higher in 1990 than respective low-level populations (Table R8-34). Impacts on all transportation services and utilities would increase at least proportionately. Some impacts would tend to compound others (e.g., inadequate air service would lead to more highway traffic). However, the eventual result of population pressures may be to precipitate the expansion and improvement of all regional transportation systems.

Socioeconomic Conditions

Sociocultural Impacts. The projected population with the high level of development is anticipated to be 26% higher in 1985 and 33% higher in 1990 than population levels associated with the low level of development (Table R8-34).

This possible higher population level would mean sociological impacts that are increased over those outlined in Chapter 4. The relationship would not necessarily be proportionate. That is, all impacts would not increase by the same percentage as the population change. There are thresholds on some impacts (water and sewage) and indiscrete levels on others (old-timer/newcomer conflict). Some impacts tend to compound themselves and add to other impacts (e.g., lack of recreational facilities can contribute to increased alcohol and drug abuse).

Therefore, the magnitude of sociological changes is difficult to predict.

Economic Impacts.

Population. Table R8-34 presents local and regional population projections under the high-level scenario. By 1990, the population of northeastern Wyoming would be 201,302 under the high-level scenario, or 11.1% greater than the projected low-level scenario population.

The relative impact of the high-level scenario would be even greater for certain counties and municipalities.

TABLE R8-32

ANNUAL UNIT COAL TRAIN VOLUME
HIGH-LEVEL SCENARIO

	Number of Unit Trains*		
	1980	1985	1990
Low-Level Scenario Mines	10,175	14,835	15,305
Buckskin Mine	200	400	400
Potential Coal Mines	0	10,100	15,600
Total	10,375	25,335	31,305

1980 daily average = 10,375 trains per year ÷ 365 = 28.4 trains per day eastbound (loaded)
28.4 trains per day westbound (empty)
1985 daily average = 25,335 trains per year ÷ 365 = 69.4 trains per day eastbound (loaded)
69.4 trains per day westbound (empty)
1990 daily average = 31,305 trains per year ÷ 365 = 85.9 trains per day eastbound (loaded)
85.9 trains per day westbound (empty)

Source: See Table R8-21.
* A unit coal train usually consists of 100 coal cars and five diesel units. Each car carries 100 tons of coal. This number does not represent full transport of the mine production by unit trains. Coal consumed at mine mouth is generally transported short distances by truck or private rail.

TABLE R8-33

DAILY TRAIN VOLUME PROJECTIONS FOR THE REGION
HIGH-LEVEL SCENARIO

Train Type	1980* Number of Trains**	1980* Percent of Total	1985 Number of Trains**	1985 Percent of Total	1990 Number of Trains**	1990 Percent of Total
Northern Route						
Total Coal Trains:	66.8	91.9	83.4	93.3	99.8	94.3
Baseline Mines***	55.7	1.5	43.7	48.9	45.0	42.5
High Alternative Mines***	1.1	75.5	28.7	32.1	43.8	41.4
"Other" Coal Trains****	11.0	14.9	11.0	12.3	11.0	10.4
Noncoal Freight Trains*****	6.0	8.1	6.0	6.7	6.0	5.7
Total Coal and Noncoal Freight Trains	73.9	100.0	89.4	100.0	105.8	100.0
Southern Route						
Total Coal Trains:	0	0	72.4	90.0	88.8	91.7
Baseline Mines***	0	0	43.7	54.3	45.0	46.5
High Alternative Mines***	0	0	28.7	35.7	43.8	45.2
"Other" Coal Trains	0	0	0	0	0	0
Noncoal Freight Trains	8	100.0	8.0	10.0	8.0	8.3
Total Coal and Noncoal Frieght Trains	8	100.0	80.4	100.0	96.8	100.0

* Train traffic expected on the Burlington Northern route in early 1980 before the Donkey Creek to Orin Junction rail strip is completed. If the rail strip were completed in 1980, about half of the coal trains originating in the Eastern Powder River Basin would move in a southerly direction toward Orin Junction.

** Includes both loaded and empty train traffic.

*** Based on Table R8-21.

**** Burlington Northern estimate of coal trains in Gillette in 1982, personal communication, Jerrold G. Wood, Director of Public Works 1978.

***** Burlington Northern freight traffic estimate for the Donkey Creek to Edgemont rail segment in 1978 and 1982, personal communication, Jerrold G. Wood, Director of Public Works 1978.

TABLE R8-34
POPULATION PROJECTIONS, 1978-1990
HIGH-LEVEL SCENARIO

County City	1978	1980	Annual Rate of Change* 1978-1980	1985	Annual Rate of Change* 1980-1985	1990	Annual Rate of Change* 1985-1990	Annual Rate of Change* 1978-1990
Campbell	16,000	18,242	(6.8)	31,473	(11.5)	39,483	(3.9)	(5.0)
Gillette	10,067	12,065	(9.5)	24,841	(15.5)	32,660	(5.6)	(10.3)
Other Areas	5,933	6,177	(2.0)	6,632	(1.4)	6,823	(0.6)	(1.2)
Converse	9,593	10,916	(6.7)	21,840	(14.8)	21,672	(-0.2)	(7.0)
Douglas	4,824	5,694	(8.6)	14,693	(21.0)	14,226	(-0.7)	(9.4)
Glenrock	2,296	2,735	(9.1)	4,667	(11.3)	4,966	(1.3)	(6.6)
Other Areas	2,483	2,487	**	2,480	**	2,480	**	**
Crook	5,148	5,442	(2.8)	6,679	(1.2)	7,350	(1.9)	(3.0)
Moorcroft	1,200	1,490	(11.3)	2,721	(12.8)	3,392	(4.5)	(9.0)
Other Areas	3,948	3,952	**	3,958	**	3,958	**	**
Johnson	6,803	6,862	(0.4)	7,312	(1.2)	7,762	(1.2)	(1.1)
Buffalo	4,400	4,455	(0.6)	4,899	(1.9)	5,349	(1.8)	(1.6)
Other Areas	2,403	2,407	**	2,413	**	2,413	**	**
Natrona	58,000	59,377	(1.2)	69,573	(3.2)	79,747	(2.8)	(2.7)
Casper	47,222	48,595	(1.4)	58,785	(3.9)	68,959	(3.2)	(3.2)
Other Areas	10,778	10,782	**	10,788	**	10,788	**	**
Niobrara	3,020	3,045	(0.4)	3,144	(0.6)	3,235	(0.6)	(0.6)
Lusk	2,000	2,021	(0.5)	2,114	(0.9)	2,205	(0.8)	(0.8)
Other Areas	1,020	1,024	**	1,030	**	1,030	**	**
Sheridan	22,501	23,713	(2.7)	28,160	(3.5)	32,827	(3.1)	(3.2)
Sheridan	13,400	14,608	(4.4)	17,043	(5.4)	23,710	(4.5)	(4.9)
Other Areas	9,101	9,105	**	9,117	**	9,117	**	**
Weston	6,932	7,493	(4.0)	8,490	(2.5)	9,226	(1.7)	(2.4)
Newcastle	3,455	4,012	(7.8)	5,003	(4.5)	5,739	(2.8)	(4.3)
Other Areas	3,477	3,481	**	3,487	**	3,487	**	**
Region	127,977	135,090	(2.7)	176,671	(5.5)	201,302	(2.7)	(3.8)

Source: University of Wyoming 1978.
* Average rate of change compounded annually.
** Average rate of change less than 0.1 %.

For instance, by 1990 Campbell County's population would by 39,483, or 37.2% greater than under the low-level scenario. Gillette would have 32,660 inhabitants by 1990 according to the same projections, or 44.5% greater than the low-level. Gillette's average annual rate of population growth under the high-level scenario would exceed 13%, or twice the historical rate of growth in the early "boom"years of 1975-78.

Converse County would also experience major population impacts as a result of the high level of coal development. Population in 1990 is forecast at 21,672, or 23.1% above the low level. This represents a small decline from the peak population of 21,840 forecast for 1985. The decline would be attributable to construction worker layoffs following completion of the coal gasification plant (also included under the low-level scenario). The population decline projected between 1985 and 1990 under the low-level scenario would be much greater than under the high level; the additional coal development forseen under the latter would have the effect of dampening an otherwise fairly drastic population decline.

Similarly, the 1985-1990 decline in Douglas' population under the low-level scenario would be largely offset by additional coal development under the high-level scenario. Under the latter, Douglas' population is projected to drop slightly from 14,693 in 1985 to 14,226 in 1990 (compared with the low-level population projections, which show a decline from 12,330 to 10,919 over the same period). This difference could have significant policy implications for Douglas. While the city still would be faced with the necessity of providing facilities and services for a greatly expanded population by 1985, the problems associated with potential overcapacity as a result of the post-1985 population decline would be much less serious.

Glenrock would have a 1990 population of 4,966 under the high-level scenario, or 17.9% above the low-level projections. Moorcroft, in Crook County, could expect 18.9% more population in 1990 under the high-level scenario than under the low level. In the remaining counties and municipalities, the population increment attributable to the high-level scenario would be less than 10%, ranging from a low of 0.5% (Niobrara County) to 7.9% in Crook County (including Moorcroft as well as other areas of the county).

Employment. Table R8-35 describes projected employment by sector in the eight-county region under the high-level scenario. The effect of accelerated coal development can be seen in the minerals extraction sector which is projected to increase from 17.8% of total employment in 1978 to 23.5% in 1990 (compared with 19.0% of total employment under the low-level scenario). Construction (including mine construction) is projected to rise from 8.2% of total regional employment in 1978 to a peak of 10.9% in 1985 at the height of mine construction, before declining to a 6.9% share in 1990. (Under the low-level scenario, construction employment was projected to peak at 9.9% before declining to 7.2% in 1990.)

Business and consumer services, while growing in absolute terms from 25,408 to 33,510 employees, are projected to decline in relative terms from 50.0% to 43.6% of total employment under the high-level scenario. Agriculture and manufacturing likewise would experience a relative decline in employment between 1978 and 1990, from 3.3% to 2.2% and from 5.4% to 4.3% respectively. Government and education, on the other hand, is projected to increase in both absolute and relative terms between 1978 and 1990, from 7,575 to 13,614 employees or from 14.9% to 17.7% of total employment.

Expected employment trends in the individual counties would mirror these developments to varying degrees. By 1990, minerals extraction is expected to account for 43.3% of total employment in Campbell County, compared with 27.6% in 1978. The percentage of mineral-related employment would be nearly as high in Converse County, i.e., 40.1% in 1990 (versus 37% in 1978). Minerals extraction is projected to account for over 30% of total employment in two other counties by 1990: Crook (31.1%) and Weston (31.3%).

In 1978, the business and consumer services sector is the largest source of employment in all eight counties. By 1990, under the high-level scenario, it would have been supplanted by minerals extraction as the largest employer in Campbell, Converse, and Crook counties. In the remaining five counties, business and consumer services is projected to remain the largest employer through 1990 under the high-level scenario. Between 1978 and 1990, this sector should increase from 41.1% to 43.5% of total employment in Johnson County and from 55.7% to 59.7% of total Natrona County employment. In Niobrara, Sheridan, and Weston counties, business and consumer services are projected to decline slightly, while remaining the largest single source of employment through 1990.

Government and education is projected to remain the third largest sector in terms of employment in each of the eight counties through 1990. Manufacturing would remain steady or decline in relative importance in every county except Niobrara and Weston. Agriculture would show an across-the-board decrease as a relative source of employment.

Income. Table R8-36 describes cumulative earnings impacts under the high-level scenario in the eight-county region. Total earnings would be expected to rise from $631.1 million in 1978 to $1,432.8 million in 1990, a total increase of 127% or 7.1% annually. (All figures are expressed in 1975 equivalent dollars.) This rate of growth would be somewhat higher than the 5.5% annual growth rate foreseen under the low-level scenario. It is anticipated that business and consumer services would remain the predominant source of earnings in the region as a whole through 1990, followed in second place by mining. However, business and consumer services would be expected to decline from 42.1% of total earnings in 1978 to 36.0% in 1990, while mining should increase from 22.5% to 29.7% of total earnings between 1978 and 1980. Construction should continue as the third largest source of regional earnings at least through 1985 (when it would account for 17.0% of total earnings), then decline in relative importance as projected energy construction projects are completed. By 1990, government/education

TABLE R8-35

EMPLOYMENT PROJECTIONS BY SECTOR
1978-1990
HIGH-LEVEL SCENARIO

	1978		1980		1985		1990	
	No.	% Total	No.	% Total	No.	% Total	No.	% Total
Agriculture	1,669	(3.3)	1,685	(3.1)	1,698	(2.7)	1,698	(2.2)
Minerals Extraction	9,064	(17.8)	10,935	(19.9)	15,605	(2.7)	18,033	(23.5)
Construction	4,167	(8.2)	4,733	(8.6)	7,888	(10.9)	5,284	(6.9)
Manufacturing	2,764	(5.4)	2,867	(5.2)	3,101	(4.3)	3,337	(4.3)
Railroads	182	(0.4)	439	(0.8)	1,023	(1.4)	1,373	(1.8)
Business/ Consumer Services	25,408	(50.0)	26,289	(47.7)	31,246	(43.4)	33,510	(43.6)
Government/ Education	7,575	(14.9)	8,093	(14.7)	11,517	(16.0)	13,614	(17.7)
Military	22	*	22	*	22	*	22	*
Total**	50,851	100.0	55,063	100.0	73,070	100.0	76,871	100.0

Sources: University of Wyoming 1978.

* Less than 0.1%.
** Totals may not add to 100.0% due to rounding.

TABLE R8-36

PROJECTED EARNINGS BY SECTOR
(MILLIONS OF 1975 DOLLARS)
1978-1990
HIGH-LEVEL SCENARIO

	1978		1980		1985		1990	
	Dollars	% Total	Dollars	% Total	Dollars	% Total	Dollars	% Total
Agriculture	15.3	(2.4)	17.8	(2.4)	18.8	(1.7)	20.0	(1.4)
Minerals Extraction	142.2	(22.5)	183.0	(25.1)	304.7	(27.2)	425.1	(29.7)
Construction	84.0	(13.3)	100.3	(13.8)	190.5	(17.0)	149.1	(10.4)
Manufacturing	41.4	(6.6)	44.4	(6.1)	52.8	(4.7)	62.5	(4.4)
Railroads	2.7	(0.4)	4.9	(0.7)	18.1	(1.1)	27.6	(1.9)
Business/ Consumer Services	265.6	(42.1)	287.7	(39.5)	386.4	(34.5)	526.6	(36.8)
Government/ Education	79.5	(12.6)	90.2	(12.4)	149.8	(13.8)	221.4	(15.5)
Military	0.4	(0.1)	0.4	(0.1)	0.5	*	0.5	*
Total**	631.1	(100.0)	728.7	(100.0)	1,121.6	(100.0)	1,432.8	(100.0)

Source: University of Wyoming 1978.

* Totals may not add to 100.0% due to rounding.

would have replaced construction as the third largest source of regional earnings, contributing 15.5% of the total. Agriculture would continue to decline in relative importance, from 2.4% of regional earnings in 1978 to 1.4% in 1990. Manufacturing is likewise projected to decline in relative terms as a source of earnings between 1978 and 1990, from 6.6% to 4.4% of the total.

Trends in projected earnings on the individual county level would mirror these developments to varying degrees. By 1990, minerals extraction would be expected to replace business and consumer services as Campbell County's largest source of earnings, generating 50% of total county earnings (compared with 32.1% in 1978). In Converse County, minerals' projected share in total 1990 earnings would be even greater, i.e., 60.4% versus 44.6% in 1978. Minerals extraction would also be the largest source of 1990 earnings in two other counties: Crook (39.0%) and Weston (40.5%).

The business and consumer services sector is projected to remain the largest source of earnings in the remaining four counties, with respective shares in total 1990 earnings ranging from 37.3% in Johnson County to 51% in Natrona County. Business and consumer services would rank second as a source of 1990 earnings in Campbell, Converse, Crook, and Weston counties.

Construction earnings as a share of total county earnings would peak sharply in Campbell and Converse counties around 1985 (at 21.5% and 36.2% of total earnings respectively). The year 1985 would fall at the height of mine construction activity in those two counties. Thereafter, as mine construction nears overall completion, construction earnings would decline significantly in Campbell and Converse counties. However, construction would remain the third largest source of earnings in Campbell County (13.8% of the total in 1990). Construction is also projected to be the third largest source of 1990 earnings in Johnson County (17.9% of the total).

Government/education would be the third largest source of 1990 earnings in Converse, Crook, Natrona, Sheridan, and Weston counties. In all eight counties, government/education would increase significantly as a proportion of total earnings between 1978 and 1990.

Among the other sectors, manufacturing should decline as a proportion of total earnings in every county except Niobrara between 1978 and 1990. Despite a relative decline in manufacturing earnings, Natrona and Weston would remain the only counties receiving more than 10% of their earnings from manufacturing through 1990. Agriculture would continue its across-the-board decline as a relative source of earnings between 1978 and 1990.

Local Services. The relative impact of the projected population for the high-level scenario on local services would vary among individual communities, according to the capacity of local services and facilities, as well as their respective shares in total regional population growth. The following discussion is concerned mainly with those communities which would experience significant additional impacts under the high-level scenario as compared with the low level. For the remaining communities, service requirements would be essentially the same as described in Chapter 4.

Gillette's municipal services, which would be strained by the population forecast under the low-level scenario, would face even more severe strains under the high level. The cumulative effect of the high level of development would necessitate an additional 38 police officers and 9 patrol cars above current levels by 1990, compared with 11 more officers and 3 additional vehicles under the low level. Unlike law enforcement, the Campbell County/Gillette Fire Department would not be significantly affected under the high-level scenario as compared with low level.

Gillette's planned water supplies (10.9 million gallons per day (mgd)), which would be adequate under the low-level scenario through 1990, would only be adequate through 1985 under the high-level scenario. By 1990, the projected high-level population growth would require a combined water supply and treatment capacity of 13.4 mgd. By 1990, the high-level population's sewage treatment requirements would be 5.4 mgd, compared with the low-level requirement of 3.0 mgd.

While Douglas' peak 1985 population under the high-level scenario would be substantially higher than under the low level, the subsequent population decline and resultant service overcapacity would present less severe problems under the high-level scenario. For example, while the high-level population would require an increase of 15 police officers by 1985 (versus 11 under the low level), the resultant total force of 25 officers would remain optimal through 1990 (under the low level, the total requirement would drop to 19 officers after 1985). Likewise, the high-level scenario would necessitate 5 additional police cars by 1985 (compared with 4 under the low level), but the total of 8 cars would be optimal through 1990 (unlike the low-level requirement of 7, which represent overcapacity after 1985).

The high-level population growth should not affect the Douglas' fire protection requirements. However, a peak water supply capacity of 6.6 mgd would be required by 1985, compared with a low-level requirement of 5.5 mgd. Likewise, in order to meet the requirements of the high-level population, Douglas would require a maximum sewage treatment capacity of 2.5 mgd by 1985, rather than the 2.0 mgd required under the low level. However, the high-level peak water and sewer requirements would represent only slight overcapacity after 1985, compared with the substantial excess sewer and water capacity found under the low level.

In Moorcroft, projected high-level police and fire protection requirements would not differ from the low-level requirements. However, under the high-level scenario, the town would need a maximum water supply capacity of 1.5 mgd (compared with 1.3 mgd under the low level). Projected high-level population growth would also necessitate a 1990 peak sewage treatment capacity of 565,000 gallons per day (gpd), higher than the low-level requirement.

In Casper, the projected high-level population would impose a minimum total requirement of 103 police officers and 27 patrol cars, compared with 99 officers and 26

vehicles under the low level. However, the incremental impact of the high-level scenario on the Casper Fire Department probably would be small.

Under the high-level scenario, Casper would require an additional 2.5-mgd water supply capacity by 1990 (a total capacity of 27.9 mgd, compared with 36.1 mgd under the low level). It would also be necessary to expand the city's current 6.5 mgd sewage treatment plant to a capacity of 11.6 mgd by 1990 under the high-level scenario, compared with a low-level requirement of 11.0 mgd.

In Sheridan, at least an additional 13 police officers (a total of 41, compared with 39 under the low level) and 5 police cars (a total of 14, versus 13 under the low level) would be required to maintain acceptable levels of police coverage for the projected 1990 high-level population. The Sheridan Fire Department has adequate manpower and equipment to meet the city's high-level fire protection requirements through 1990.

Sheridan's water supply and treatment capacity would have to be expanded from the current 10.0 mgd to 10.7 mgd by 1990 to meet projected high-level demand, compared with the low-level requirement of 10.2 mgd by 1990. However, the city's current 5.0 mgd-capacity sewage treatment plant should remain adequate through 1990 under either the high- or low-level scenario.

The Newcastle Police Department should add at least 3 officers to the force by 1990 (making a total of 12 officers) to meet the requirements of the high-level population, compared with the low-level requirement for 11 officers. Under either scenario, the department would require 1 additional patrol car by 1990. The high-level population should not affect the fire department's requirement for an additional 500-gallon-per-minute pumper truck and 60 additional volunteer firemen.

In order to provide adequate water supplies for the projected 1990 high-level population, Newcastle would require a peak water supply capacity of 4.9 mgd (compared with a currently planned capacity of 4.4 mgd, and a low-level requirement of 4.7 mgd). Under the high-level scenario, Newcastle's lagoon sewage treatment facility would have to be supplanted by a facility capable of processing 960,000 gpd, compared with the low-level requirement of 900,000 gpd by 1990.

Housing. Table R8-37 shows the projected growth of housing demand in regional communities under the high-level scenario, compared with historical growth rates in the local housing stock. Communities which would experience significant incremental housing impacts under the high-level scenario compared with the low level are Gillette, Douglas, and Glenrock. In Gillette, total housing demand would be expected to increase at an average annual rate of 7.6% under the high-level scenario, compared with 5.5% annually under the low level. Local demand for single-family housing, which would increase at an average rate of 6.0% under the low level, would be expected to grow by 10.4% annually under the high-level scenario. In Douglas and Glenrock, total housing demand under the high level is projected to grow at average annual rates of 8.5% and 8.1% respectively, compared with projected low-level growth rates of 6.5% and 7.6%. However, like Gillette, Douglas and Glenrock would experience considerably higher incremental annual growth rates in demand for single-family housing: 7.7% (high level) versus 3.6% (low level) in Douglas; and 8.5% versus 4.3% in Glenrock. The relatively rapid growth in demand for single-family housing would be to the large percentage of highly paid mining and construction workers among the new arrivals in these communities.

Based on the historical rate of growth in single-family housing in Douglas (comparable data for Glenrock are not available), the housing markets in Douglas and Glenrock would appear capable of meeting projected high-level demand. However, in Gillette, the stock of single-family housing would have to increase at twice its historical rate of growth in order to meet the demand of those desiring and able to afford single-family housing.

Under the low-level scenario, it was estimated that between 60% and 70% of the households in Gillette, Douglas, and Glenrock desiring single-family housing could afford it. Under the high-level scenario, this percentage should increase slightly due to the higher representation of highly paid mining and construction workers.

Education. Table R8-38 depicts projected school enrollment increases under the high-level scenario. The following paragraphs discuss the implication of these projected increases for individual school districts, particularly in comparison with the projected low-level population increases.

According to projections in Table R8-38, the Gillette School District would experience the greatest absolute and relative enrollment increase under the high-level scenario: 2,843 additional pupils, or 35% above the projected low level by 1990. Such an increase would have major implications for the district's building program. While current facilities and planned expansions could accommodate the projected high-level enrollment through the 1981-82 school year, between 1982 and 1990 space would have to be made available for an additional 4,036 pupils (compared with 1,193 under the low level). To maintain current pupil/teacher ratios, the school district would also have to hire an additional 445 teachers between 1978 and 1990 under the high level, versus 249 under the low level.

The Douglas School District would also experience significant additional impacts under the high-level scenario. By 1985, the year of peak enrollment, the incremental enrollment attributable to the high level would be 669, or 16% above low-level projections. To accommodate this increase, the district would have to provide an additional 2,089 pupil spaces (compared with 1,420 under the low level). One option open to the school district under the low level would be the use of temporary (mobile and modular) classrooms to get over the 1985 enrollment "hump"without long-term excess capacity. Under the high-level scenario, the post-1985 enrollment decline would be smaller than under the low level (128 versus 413). This means that not only are the short-term space requirements greater under the high-level, but also a larger percentage of the short-term increase should be

TABLE R8-37

PROJECTED HOUSING DEMAND
1978-1990
HIGH-LEVEL SCENARIO

Community/ Housing Type	1977 Housing Stock	Average Annual Growth Rate of Housing Stock 1970-77*	Additional Demand for Housing Units 1977-1990 Total No. of Units	Average Annual Growth of Housing Stock Required 1977-90*
Gillette				
Single-family	1,623	5.2%	4,223	10.4%
Multi-unit	680	6.3%	597	5.0%
Mobile	1,542	13.3%	1,331	4.9%
Total all types	3,845	8.1%	6,151	7.6%
Douglas				
Single-family	1,232	6.5%	1,999	7.7%
Multi-unit	207	0.7%	399	8.6%
Mobile	349	24.8%	973	10.8%
Total all types	1,788	8.2%	3,371	8.5%
Glenrock				
Single-family	439	NA	822	8.5%
Multi-unit	63	NA	120	8.6%
Mobile	159	NA	212	6.7%
Total all types	661	3.7%	1,154	8.1%
Moorcroft				
Single-family	147	NA	364	10.0%
Multi-unit	0	NA	79	0
Mobile	150	NA	269	8.2%
Total all types	297	NA	712	9.9%

TABLE R8-37
(cont'd)
PROJECTED HOUSING DEMAND
1978-1990
HIGH-LEVEL SCENARIO

Community/ Housing Type	1977 Housing Stock	Average Annual Growth Rate of Housing Stock 1970-77*	Additional Demand for Housing Units 1977-1990 Total No. of Units	Average Annual Growth of Housing Stock Required 1977-90*
Buffalo				
Single-family	1,398	4.8%	73	0.4%
Multi-unit	93	-12.0%	56	3.2%
Mobile	130	11.4%	217	7.8%
Total all types	1,621	3.3%	346	1.5%
Casper				
Single-family	12,034	2.3%	2,213	1.3%
Multi-unit	3,580	3.0%	1,162	2.2%
Mobile	655	18.1%	3,727	15.8%
Total all types	16,269	2.8%	7,102	1.3%
Lusk				
Single-family	NA	NA	17	NA
Multi-unit	NA	NA	22	NA
Mobile	NA	NA	93	NA
Total all types	720	0.2%	132	1.3%
Sheridan				
Single-family	3,993	2.1%	633	1.2%
Multi-unit	477	-3.0%	514	5.8%
Mobile	780	45.7%	2,165	10.8%
Total all types	5,250	2.4%	3,312	3.8%
Newcastle				
Single-family	950	0.4%	424	2.9%
Multi-unit	246	6.1%	79	2.2%
Mobile	172	9.9%	258	7.3%
Total all types	1,368	1.6%	761	3.2%

Note: See Table R4-16 for methodology used in making these projections.
* Compounded annually
NA = Not available

TABLE R8-38

PROJECTED SCHOOL DISTRICT ENROLLMENTS
1980-1990
HIGH-LEVEL SCENARIO

	1980				1985				1990			
	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total
Campbell												
Gillette	2,858	1,146	1,045	5,050	4,929	1,977	1,803	8,709	5,202	2,487	2,268	10,957
Converse												
Douglas	1,262	483	409	2,154	2,793	1,068	906	4,767	2,718	1,039	881	4,639
Glenrock	509	240	216	965	785	371	334	1,489	827	391	352	1,570
Crook												
Sundance	714	359	334	1,408	874	439	410	1,723	963	484	452	1,899
Johnson												
Buffalo	763	334	324	1,420	812	355	345	1,512	862	377	366	1,605
Natrona												
Casper	7,320	3,307	3,505	14,132	8,577	3,875	4,106	16,558	9,832	4,441	4,707	18,980
Niobrara												
Lusk	304	155	161	621	313	160	166	641	323	165	172	660
Sheridan												
Ranchester	361	188	189	738	362	189	189	740	361	191	189	742
Sheridan	2,009	961	872	3,842	2,619	1,252	1,137	5,008	3,261	1,559	1,416	6,236
Clearmont	89	21	34	144	89	22	34	145	89	22	35	146
Weston												
Newcastle	713	324	353	1,390	808	367	400	1,575	878	399	435	1,712
Upton	245	107	106	458	278	123	118	519	302	133	130	565

Source: University of Wyoming 1978.

accommodated in permanent rather than temporary quarters. Under the high-level scenario, the district would also need to hire some 160 additional teachers by 1985, of which 150 to 155 would be long-term appointments beyond 1985. The corresponding figures under the low level would be 123 and 100 teachers respectively.

The Casper School District would also have to step up its already active building program if it is to accommodate the 18,980 pupils projected by 1990 under the high-level scenario (compared with 18,205 under the low level). Projected high-level enrollment increases would require an additional 2,400 pupil spaces by 1990 over and above currently planned expansion, compared with 1,600 more spaces under the low level. To maintain current pupil/teacher ratios under the high level, the district would also need to hire 235 additional teachers by 1990 (compared with approximately 200 under the low level).

Projected incremental impacts of the high-level scenario on other school districts in the eight-county region would be less significant when compared with the low level. Additional space requirements beyond those required under the low level, if any, could be satisfied through expansion of existing buildings and the use of temporary classrooms rather than by the construction of new buildings. Incremental teacher requirements would also be correspondingly smaller.

Health Care. Table R8-39 projects the number of additional physicians, dentists, and nurses needed under the high-level scenario to provide adequate levels of health care to the local population through 1990. According to the table, the region would need 69 more doctors by 1990 (versus 49 under the low level) and 64 more dentists (versus 51 under the low level). In addition, the eight-county region, which would be expected to enjoy an overall surplus of registered nurses through 1990 under the low level, would need to recruit 8 additional registered nurses under the high level.

On the individual county level, Natrona County would enjoy the most favorable health manpower situation in the eight-county region. However, while Natrona County is projected to have sufficient doctors and nurses to meet high-level requirements through 1990, it would need to recruit 16 additional dentists (versus 14 under the low level). The need for additional health care specialists to meet high-level requirements would be more acute in other counties, particularly Campbell, Converse, Crook, and Weston counties. Campbell County would have to recruit 30 additional physicians (compared with 20 under the low level), 21 dentists (versus 14 under the low level), and 56 nurses (compared with 48 under the low level). In Converse County, the high-level requirements compared with low-level requirements (in parentheses) would be 18 more doctors (12), 12 additional dentists (9), and 47 more nurses (33).

Hospital bed needs, in contrast to health care manpower, are addressed on an eight-county basis. Taking into account the capacity of existing hospital facilities, those under construction, and those planned for the future, the eight-county region would face a deficit of 280 beds by 1990 (compared with 193 under the low level), unless it can improve average bed utilization factors.

Retail Trade. It is assumed that future per capita retail expenditures in the eight-county region, measured in constant 1975 dollars, would continue to grow at the historical rate of 0.7% annually through 1990 (see Chapter 2). On this basis, total 1990 retail sales in the region are projected at approximately $732.1 million (1975 dollars) under the high-level scenario, a 93% increase since 1975.

It is expected that Natrona County (i.e., Casper) would continue as the region's main trade center through 1990. Natrona County captured more than 50% of all new retail trade in the region between 1972 and 1977. However, the growth of other secondary trade centers (particularly in neighboring Converse County, which should experience rapid population increases in the next decade), would be expected to reduce Natrona County's relative attractiveness as a trade center. In view of this, total 1990 retail sales in Natrona County are estimated at $290.0 million (1975 dollars), or approximately 40% of total regional sales.

Campbell County (Gillette) and Sheridan County (city of Sheridan) in recent years have emerged as secondary trade centers in their own right. Between 1972 and 1977, both enjoyed shares in regional sales approximately proportional to their respective percentages of regional population. On a similar basis, 1990 retail sales in Campbell County are estimated at $143.6 million (1975 dollars), and in Sheridan County at $119.4 million (1975 dollars).

Due to its large increase in population, Converse County by the mid-1980s might also attain the status of a secondary trade center, able to supply the greater part of its residents' retail needs and attracting shoppers from neighboring counties. As such, Converse County might experience annual retail sales up to $78.8 million (1975 dollars) by 1990, concentrated in Douglas and, to a lesser extent, Glenrock.

Local Finances. As is the case under the low level, the incremental effects of the high-level population growth on local communities' operating and capital balances would vary. The large property tax base at their disposal should enable the county governments and school districts to meet the service and educational requirements of the projected high-level population through 1990.

Municipalities would vary in their ability to cope with the fiscal demands of population growth. Most municipalities, including Gillette, appear able to finance their operating expenditures through 1990, assuming a continuation of state and federal transfers at approximately current levels. However, Douglas, Glenrock, and Moorcroft would all face significant operating shortfalls in the 1980s unless new sources of local or outside funding can be secured. In the case of Douglas, the potential shortfall would be expected to approach $1.2 million per year (compared with $1 million under the low level) by 1985. Glenrock and Moorcroft would face smaller, but still significant annual shortfalls of nearly $60,000 and $30,000 respectively (compared with $50,000 and $25,000 respectively under the low level) by the late 1980s. The opportunities for Douglas and Glenrock to raise additional local revenues by levying additional taxes would be

TABLE R8-39

PROJECTED HEALTH CARE PERSONNEL REQUIREMENTS
HIGH-LEVEL SCENARIO

	1977 Physicians	Physicians Recommended Levels*			1977 Registered Nurses	Registered Nurses Recommended Level**			1977 Dentists	Dentists Recommended Level***		
		1980	1985	1990		1980	1985	1990		1980	1985	1990
Campbell	9	18	31	39	53	64	110	139	4	11	20	25
Converse	6	11	22	22	29	38	77	76	2	7	14	14
Crook	2	5	7	7	11	19	23	26	1	3	4	5
Johnson	4	7	7	8	30	24	26	27	2	4	5	5
Natrona	80	59	70	80	383	208	244	280	34	37	43	50
Niobrara	2	3	3	3	12	11	11	11	1	2	2	2
Sheridan	26	24	28	33	154	83	99	115	16	15	18	21
Weston	3	7	8	9	26	26	30	32	2	5	5	6
Region	132	135	177	201	698	474	620	706	62	84	110	126

Source: Wyoming Department of Health and Social Services 1977; personal communication, Larry Bertilson, State Health Planning Manager 1978.

* Based on recommended standard of 1,000 persons per physician.
** Based on recommended standard of 285 persons per registered nurse.
*** Based on recommended standard of 1,600 persons per dentist.

TABLE R8-40

COMPARISON TABLE OF IMPACTS
(Partial Listing)

	Units	Regional Cumulative			Cumulative No Action Alternative Low-Level Scenario			Cumulative High-Level Scenario		
		1980	1985	1990	1980	1985	1990	1980	1985	1990
Air Quality-Estimated total particulate emissions from major man-made sources	Tons/year	60,422	72,716	77,104	59,660	71,541	75,739	61,470	107,610	131,274
Paleontology-loss of fossils due to collecting and mining	Acre-feet	2,526,146	5,818,017	9,074,918	2,521,106	5,756,337	8,984,438	2,526,146	>10,500,000	>16,500,000
Topography-surface disturbed (total)	Acres	23,274	41,931	52,803	22,872	41,293	52,045	26,206	58,603	84,825
Soil-reduced productivity	Acres	23,274	41,931	52,803	22,872	41,293	52,045	26,206	58,603	84,825
Soil-soil surface required for increased population	Acres	400	1,800	2,200	300	1,700	2,100	400	2,800	3,600
Water-estimated water withdrawal	Acre-feet	53,630	67,890	70,450	53,550	67,810	70,370	53,930	84,140	93,700
Water-projected change in water use (Base year - 1975)	Acre-feet	9,390	23,650	26,210	9,310	23,570	26,130	9,690	39,900	49,460
Vegetation-acres of vegetation removal	Acres	23,274	41,931	52,803	22,872	41,293	52,045	26,206	58,603	84,825
Vegetation-acres of disturbed land which would be reclaimed	Acres	4,895	13,437	18,966	4,895	13,437	18,952	4,895	15,228	26,566

TABLE R8-40
(cont'd)

COMPARISON TABLE OF IMPACTS
(Partial Listing)

	Units	Regional Cumulative			Cumulative No Action Alternative Low-Level Scenario			Cumulative High-Level Scenario		
		1980	1985	1990	1980	1985	1990	1980	1985	1990
Wildlife-loss of fish and wildlife habitat and carrying capacity-direct	Acres	23,274	41,931	52,803	22,872	41,293	52,045	26,206	58,603	84,825
Wildlife-loss of fish habitat and carrying capacity affected-indirect	Acres	104,733	188,690	237,614	102,924	185,819	234,203	117,927	263,714	381,713
Wildlife-estimated loss of nongame birds	Number birds	118,697	213,848	269,295	116,647	210,594	265,430	133,651	298,875	432,608
Wildlife-estimated loss of raptor numbers	Number raptors	131	236	297	129	232	293	147	330	477
Wildlife-total estimated loss of nongame mammals	Millions mammals	88,441	159,338	200,651	86,914	156,913	197,771	99,583	222,691	322,335
Wildlife-number of antelope lost	Number antelope	748	1,351	1,702	743	1,342	1,691	852	1,905	2,757
Wildlife-number of deer lost	Number deer	107	194	245	107	194	244	123	175	398
Visual-VRM class change from present on disturbed lands	Acres	23,274	41,931	52,803	22,872	41,293	52,045	26,206	58,603	84,825

TABLE R8-40
(cont'd)

COMPARISON TABLE OF IMPACTS
(Partial Listing)

		Regional Cumulative			Cumulative No Action Alternative Low-Level Scenario			Cumulative High-Level Scenario		
	Units	1980	1985	1990	1980	1985	1990	1980	1985	1990
Recreation-number of recreation visitor days for all activities	Visitor days (millions)	1.276	1.633	1.991	.931	1.551	1.911	1.276	2.531	3.265
Agriculture-number of AUMs lost	AUMs	4,654	8,386	10,560	4,574	8,258	10,409	5,241	11,720	16,965
Minerals-annual coal production	Million tons	109	169	173	107	165	169	109	270	329
Transportation-estimated vehicle registrations, increase over 1975 numbers	Vehicles	47,000	84,000	99,000	47,000	83,000	98,000	47,000	106,000	132,000
Transportation-increase in number of coal trains eastbound	Trains/ day	17.7	34.1	35.4	17.2	33.0	34.3	17.7	61.7	78.7
Transportation-increase in number of trains westbound	Trains/ day	17.7	34.1	35.4	17.2	33.0	34.3	17.7	61.7	78.7
Socioeconomic-total increase in population since 1978	People	7,007	34,831	53,943	6,904	34,372	53,200	7,113	48,694	73,325
Socioeconomic-total increase in employment since 1978	Jobs	3,994	12,688	16,606	3,733	12,528	16,344	4,212	21,219	26,020

TABLE R8-40
(cont'd)

COMPARISON TABLE OF IMPACTS
(Partial Listing)

	Units	Regional Cumulative			Cumulative No Action Alternative Low-Level Scenario			Cumulative High-Level Scenario		
		1980	1985	1990	1980	1985	1990	1980	1985	1990
Socioeconomic-total increase in income since 1978	Million dollars	96.6	348.0	583.6	89.5	328.9	569.4	97.6	490.5	801.7
Socioeconomic-increase in retail sales since 1978	Million dollars	29.4	142.2	230.9	29.4	142.2	230.9	30.1	192.6	304.1
Socioeconomic-additional units of housing needed	Housing units			17,664			17,358			19,401
Socioeconomic-increased school enrollment	Students	1,854	9,329	14,072	1,827	9,118	13,873	1,791	12,885	19,180
Socioeconomic-increased number of physicians and dentists needed	Doctors and dentists	25	69	100	25	69	100	25	93	133
Socioeconomic-increased number of law enforcement personnel needed	Law officers	2	47	34	2	46	34	2	65	47

rather limited, since Converse County already levies the optional 4% sales tax, and neither can increase its general purpose property tax levies much further. Addition of the 4% optional sales tax in Crook County would help redress Moorcroft's prospective operating shortfall. Otherwise, these communities would have to either turn to the state or federal governments for financial assistance, or cut back on service levels, in order to avoid chronic operating deficits.

The additional population growth foreseen under the high-level scenario would also affect some local communities' capital requirements. In general, the high-level population growth would increase the needed service capacity of the facilities which these communities must provide, rather than requiring new types of facilities. As a result, Gillette's anticipated captial deficit would rise from a low-level figure of $7 million to $10-$11 million, depending on the cost of securing additional water supplies. Other communities' capital requirements under the high-level scenario (mainly for additional water supplies and sewage treatment facilities) would be as follows: Douglas—$6 million (compared with the low-level needs of $5 million); Moorcroft—$1 million (versus $500,000 under the low level); Casper—$11 million (compared with $8 million under the low level); and Sheridan—$800,000 (only minor expenditures under the low level). With the exception of Sheridan, these expenditures would be beyond local financing capabilities through either current revenues or bonded debt. Possible outside sources of financial assistance include state coal tax funds, the U.S. Farmers' Home Administration, or Environmental Protection Agency, as well as the private coal companies.

CHAPTER 9

CONSULTATION AND COORDINATION

TEAM ORGANIZATION

The Associate Director of the Bureau of Land Management (BLM) assigned the Wyoming State Director of the BLM lead responsibility for preparation of this environmental statement (ES). With guidance from the BLM Wyoming State Office, procedures and schedules for the effort were developed. Team members from the BLM, the U.S. Geological Survey (USGS), and the U.S. Forest Service (USFS) were selected.

BLM provided professional specialists in the fields of air quality, wildlife, cultural resources, recreation, and socioeconomics. USGS provided professionals in the fields of geology, paleontology, hydrology, and mining engineering. USFS provided professionals in soils, vegetation, and agriculture.

The following consultant services were secured by contract. Centaur Management Consultants, Inc., Washington, D.C., developed the rail transportation and economic sections for the Regional ES. Radian Corporation, Austin, Texas, provided the sections on climate and air quality for the Regional ES. PEDCo Environmental, Cinncinati, Ohio, developed the site-specific climate and air quality sections.

PUBLIC COMMENTS AND RESPONSES

In early 1977, the BLM held the following public meetings for the purpose of discussing land use plans for the Eastern Powder River Basin: January 31, 1977, Federal Building, Casper, Wyoming, 1:00 p.m.; February 1, 1977, Recreation Center, Gillette, Wyoming, 3:00 p.m. and 7:00 p.m.; February 2, 1977, St. James Parish Hall, Douglas, Wyoming, 3:00 p.m. and 7:00 p.m. A total of 285 people attended the five meetings. Oral and written comments resulting from those meetings were analyzed before the final land use plan was issued in July 1977. The rate and location of future coal development in the basin were the subjects that caused the most concern.

Public hearings are scheduled to obtain comments on this draft ES. Specific dates and places have been announced in news releases and *Federal Register* notices.

Copies of this draft ES are available upon request (until supplies are exhausted) from Wyoming State Office, Bureau of Land Management, P.O. Box 1828, 2515 Warren, Cheyenne, Wyoming 82001.

CONSULTATION AND COORDINATION IN THE PREPARATION OF THE DRAFT ENVIRONMENTAL STATEMENT

During preparation of the draft ES, members of the team consulted personnel from the following federal, state, and local agencies:

Bureau of Land Management
Federal Aviation Authority
Interstate Commerce Commission
National Park Service
U.S. Bureau of Mines
U.S. Fish and Wildlife Service
U.S. Forest Service (Bighorn and Black Hills National Forests and Thunder Basin National Grasslands)
U.S. Geological Survey
University of Wyoming
Wyoming Department of Environmental Quality provided information about the status of existing or already approved mines in the Eastern Powder River Basin, and suggested a list of mitigating measures considered feasible for mined land reclamation.
Wyoming Department of Economic Planning and Development
Wyoming Department of Health and Social Services
Wyoming Department of Revenue and Taxation
Wyoming Game and Fish Department provided wildlife population data, statistics for big game and upland game harvests and numbers of hunters, and maps of big game ranges.
Wyoming Geological Survey
Wyoming Highway Department
Wyoming Recreation Commission
Wyoming State Engineer
Campbell County Parks and Recreation Department
Converse County Parks Commission
Converse Area Planning Office
Natrona County International Airport
Sheridan County Planning Office
Tri-County Planning Office
Casper Board of Public Utilities
City of Buffalo
City of Casper
City of Gillette/Campbell County Department of Planning and Development
City of Grand Island
City of Lusk
City of Moorcroft
City of Sundance
Douglas Recreation Center

Gillette-Campbell County Airport
Lincoln Public Services Commission
Representatives of the following private industries and groups provided additional information:
Amax Coal Company
Armco Steel
Atlantic Richfield Company
Burlington Northern Railroad
Carter Oil Company
Cordero Mining Company
Fort Fetterman Sportsmen's Association
Mountain Bell
Pacific Power and Light Company
Panhandle Eastern Pipe Line Company
Torrington Chamber of Commerce
Trailways Bus System
Union Pacific Railroad
Wyoming Manufactured Housing Association

COORDINATION IN THE REVIEW OF THE DRAFT ENVIRONMENTAL STATEMENT

Comments on the draft ES have been requested from the following agencies and interested groups.

Federal

Advisory Council on Historic Preservation
Department of Agriculture
Soil Conservation Service
U.S. Forest Service
Department of Commerce
Department of Energy
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Bureau of Mines
Bureau of Reclamation
Fish and Wildlife Service
Heritage Conservation and Recreation Service
National Park Service
Office of Surface Mining
Department of Labor
Mining Safety and Health Administration
Occupational Safety and Health Administration
Department of Transportation
Environmental Protection Agency
Federal Power Commission
Interstate Commerce Commission
Mountain Plains Federal Regional Council
National Historic Preservation Council
Office of Economic Opportunity
Office of Management and Budget
Water Resource Council

State

State of Wyoming Clearing House will coordinate comments from all interested state agencies.

Local

Campbell County Commissioners
City of Gillette-Campbell County Department of Planning and Development

Converse Area Planning Office
Converse County Commissioners
Mayor, City of Douglas
Mayor, City of Gillette
Mayor, City of Glenrock

Nongovernment Organizations

American Institute of Mining and Metallurgical Engineers
American Mining Congress
American Sportsmen's Club
Campbell County Gem and Mineral Society
Campbell County Historical Society
Campbell County Rod and Gun Club
Citizens for Orderly Energy Development
Defenders of Wildlife
Fort Fetterman Sportsmen's Association
Friends of the Earth
Izaak Walton League
League of Women Voters
Members of the Casper District BLM Advisory Board
Murie Audubon Society
National Audubon Society
National Council of Public Land Users
National Energy Law and Policy Institute
National Environmental Health Assocation
National Resources and Environmental Council
National Wildlife Federation
Natural Resources Defense Council
Outdoors Unlimited
Powder River Basin Resource Council
Powder River Wildlife Club
Rocky Mountain Center of the Environment
Shell Oil Company
Sierra Club
Society for Range Management
The Wilderness Society
Thunder Basin Grazing Association
Wyoming Archeological Association
Wyoming Association of Conservation Districts
Wyoming Environmental Council
Wyoming Outdoor Coordinating Council
Wyoming Petroleum Association
Wyoming Stock Growers Association
Wyoming Wildlife Federation
Wyoming Wool Growers Association

WHERE COPIES CAN BE INSPECTED

Copies of the draft ES will be available for public review at the locations listed below and upon request from the Bureau of Land Management in Cheyenne, Wyoming as long as supplies last.

Bureau of Land Management

Buffalo Resource Area Office

Buffalo, Wyoming 82834
(307) 684-5586
Casper District Office
951 Union Blvd.
Casper, Wyoming 82601
(307) 265-5550
Cody Resource Area Office
Cody, Wyoming 82414
(307) 587-2216
Denver Service Center Library
Bldg. 50, Denver Federal Center
Denver, Colorado 80225
(303) 234-4578
Kemmerer Resource Area Office
Diamondville, Wyoming 82116
(307) 877-3933
Lander Resource Area Office
Lander, Wyoming 82520
(307) 332-4220
Newcastle Resource Area Office
214 W. Main
Newcastle, Wyoming 82701
(307) 746-4453
Pinedale Resource Area Office
Molyneux Building
Pinedale, Wyoming 82941
(307) 367-4358
Rawlins District Office
1300 Third Street
Rawlins, Wyoming 82301
(307) 324-7171
Rock Springs District Office
Highway 187N
Rock Springs, Wyoming 82901
(307) 382-5350
Washington Office of Public Affairs
18th and C Street
Washington, D.C. 20240
(202) 343-4151
Worland District Office

1700 Robertson Avenue
Worland, Wyoming 82401
(307) 347-6151
Wyoming State Office
2515 Warren (Lea Building)
Cheyenne, Wyoming 82001
(307) 778-2220 Ext. 2385

U.S. Geological Survey

Area Mining Supervisor's Office
3 Seventh Street West
Building B, Room 200
Billings, Montana 59101
(406) 657-6181
Director's Office, National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092
(703) 860-7411
District Engineer's Office
Federal Building
100 East B Street
Casper, Wyoming 82601
(307) 265-5550
Regional Manager's Office
7200 W. Alameda Avenue
Lakewood, Colorado 80226
(303) 234-2855

U.S. Forest Service

Office of the Supervisor
Medicine Bow National Forest
605 Skyline Drive
Laramie, Wyoming 82070
(307) 745-7308
Thunder Basin National Grasslands District Office
809 South Ninth Street
Douglas, Wyoming
(307) 358-4690

Public Libraries

Albany County Library
405 Grand Avenue
Laramie, Wyoming 82070
(307) 745-8070
Carbon County Library

Courthouse
Rawlins, Wyoming 82301
(307) 324-4756
Casper College Library
335 College Drive
Casper, Wyoming 82601
(307) 268-2408
Coe Library
University of Wyoming
Laramie, Wyoming 82071
(307) 766-2174
Converse County Library
300 Walnut
Douglas, Wyoming 82633
(307) 358-3644
Crook County Library
122 North Fourth Street
Sundance, Wyoming 82729

(307) 283-1006
George Amos Memorial Library
412 South Gillette Avenue
Gillette, Wyoming 82716
(307) 682-3223
Johnson County Library
90 North Main Street
Buffalo, Wyoming 82834
(307) 684-7888
Natrona County Library
307 East Second Street
Casper, Wyoming 82601
(307) 2359272
Niobrara County Library
467 South Main Street
Lusk, Wyoming 82225
(307) 334-3490
Platte County Library
904 Ninth Street
Wheatland, Wyoming 82201
(307) 322-2689
Sheridan County Fulmer Public Library
320 North Brooks

Sheridan, Wyoming 82801
(307) 674-8585
Weston County Library
23 West Main Street
Newcastle, Wyoming 82701
(307) 746-2206

APPENDIX B

SOILS

Soil Association Descriptions

Bankard-Haverson-Kim-Riverwash-Association (No. 1)

This unit occurs as nearly-level, well-drained, deep soils on the floodplains and alluvial fans. Soils in this association developed in alluvium along sandy, shifting bottomlands and along rivers and major streams. They may occupy undulating fans, terraces, and bottomlands.

The Bankard series is on the floodplains, fans, and level terraces; Haverson soils are situated on the bottomlands; and Kim soils are found on alluvial fans below upland areas.

The soils of this association are moderately alkaline and subject to flooding during spring and early summer. They are highly susceptible to wind erosion. The acreage of this soil association is estimated to be 184,134 acres.

Razor-Shingle Association (No. 2)

This unit includes very shallow to moderately deep, well-drained, loamy, sandy, and clayey soils from sandstone and shale on sloping to steep uplands.

This association consists primarily of shallow soils and bedrock exposures on steeply sloping badlands bordering the larger streams and in areas where the bedrock has been uplifted. Shingle soils are less than 20 inches deep to shale and sandstone bedrock. Razor soils are 20 to 40 inches deep to shale or siltstone bedrock. These soils produce very little vegetation. Revegetation opportunities are very poor, and the soils are highly erodible. The acreage of this soil association is estimated to be 351,228 acres.

Renohill-Maysdorf-Ulm Association (No. 3)

This unit represents moderately deep to deep, well-drained, loamy, sandy, and clayey soils on level to nearly level alluvial fans and sloping to steep uplands.

This association consists of moderately deep soils interspersed with deep, medium to fine-textured soils. Renohill soils occur on ridgetops and ridgecrests; Ulm soils are situated on nearly level upland fans and terraces; and Maysdorf soils are found on moderately sloping upland hills and valley sideslopes.

Soils of this association are highly erodible. Productivity potential is considered moderate. The acreage of this soil association is estimated to be 378,745 acres.

Unnamed Association (No. 4)

These soils are known to be deep to shallow, well drained, loam and clay loam on gently sloping alluvial fans and sloping to moderately steep uplands.

Soil series names have not been identified for these soils; however, the following information can be assumed from their classification. These soils are considered to be mostly medium textured, including textural families of fine loamy and fine. Depth is variable, ranging from less than 20 inches to greater than 40 inches over bedrock. The clay fraction of the fine family has montmorillonitic minerology. The representative soils of this unit range from (1) Ustollic Paleargids, fine, montmorillonitic, mesic, indicating relict soils on the oldest stable erosion surfaces with fine-textured B horizons having abrupt upper boundaries, (2) Ustollic Haplargids, fine loamy, mixed, mesic, shallow, medium-textured soils less than 20 inches to soft bedrock with normal illuvial B horizons having simple morphology, and, (3) Ustic Torriorthents, fine loamy, alluvial or eolian; they have little pedogenic development. Productivity is assumed to be low to moderate; erodibility is high. The estimated acreage of this soil association is 250,382.

Renohill-Terry-Shingle Association (No. 5)

The soils are moderately deep and shallow, well drained, fine sandy loam, loam, and clay loams on moderately steep to steep uplands, ridges, and sidehills.

Renohill soils are moderately deep, fine-textured soils on ridgetops and underlain by shale. Terry soils are moderately deep, moderately coarse-textured soils occurring on side slopes and underlain by sandstone. Shingle soils are shallow and occur on steep upland ridges, usually dissected with numerous drainages and underlain with shale.

These soils are highly erodible and have low productivity potentials. The estimated acreage of the association is 280,102 acres.

Renohill-Wyarno-Cushman Association (No. 6)

These soils are deep and moderately deep, well-drained loam and clay loams on nearly level to sloping alluvial fans and gently sloping to moderately steep uplands. They overlie interbedded sandstones, shales, and siltstone.

Renohill soils are moderately deep, fine textured, and occur on ridgetops and ridgecrests; Wyarno soils are deep, well drained, and formed in alluvium; and Cushman soils are moderately deep and occupy moderately steep upland positions underlain by soft sandstone at depths of 30 inches. Productivity potential is considered to be moderate and erodibility is high. The estimated acreage is 259,441 for the association.

Wibaux Association (No. 7)

This unit is dominantly shallow but includes very shallow to moderately deep, well-drained sandy loam, clay loam, and channery loam soils on sloping to steep uplands and rough, broken land with shallow, sandy to medium-textured soils. This association occupies rolling to steep topography. It is characterized by numerous outcrops of scoria and scoria chips in the profile. Thirty to 60% of the surface has large scoria clinkers. These soils are highly erodible, and the productivity potential is low. The estimated acreage of this association is 220,274.

Renohill-Wibaux-Tassel-Shingle-Rockland Association (No. 8)

This unit includes shallow and moderately deep, well-drained sandy loam, clay loam, clay, and channery loam soils on sloping to steep uplands and rough, broken land with shallow, sandy to medium-textured soils.

The Renohill soils are moderately deep, fine textured, and occur on ridgetops and ridgecrests; Wibaux soils are shallow, well drained, medium textured, and gravelly, occurring on sloping to steep uplands; and Tassel and Shingle soils are shallow, sandy soils on rolling to steeply rolling slopes. Rockland within the unit consists of miscellaneous soil materials that are sandy to clayey on steep, broken slopes with exposed bedrock.

These soils are moderately to highly erodible with productivity potentials low to moderate. Acreage estimated for this association is 145,124.

Renohill-Cushman Association (No. 9)

This unit includes moderately deep, well-drained loam and clay loam soils on nearly level to moderately steep uplands. The Cushman soils are moderately deep soils on nearly level to gently sloping upland plains, while Renohill soils are situated on ridges and side slopes. Productivity potential and erodibility are considered moderate. The estimated acreage of the association is 275,548.

Renohill-Shingle-Terry Association (No. 10)

This association occupies the steep to very steep upland ridges and sidehills which are usually dissected with numerous drainages. The Renohill soils are moderately deep and fine textured and occur on ridgetops and ridgecrests. The Shingle and Terry soils are shallow and moderately deep, medium-textured to moderately coarse-textured soils of steeply sloping sidehills. Productivity potential is low and erodibility is high. The estimated acreage of this association is 148,224.

Renohill-Briggsdale-Ulm Association (No. 11)

This unit is represented by deep and moderately deep, well-drained loam, clay, and clay-loam soils on nearly level to sloping alluvial fans and nearly level to moderately steep uplands.

The Briggsdale and Renohill soils occur on nearly level to moderately steep uplands underlain by soft shale at depths of about 20 inches. The Ulm soils are situated on nearly level upland fans and terraces which are subject to short periods of overflow in the spring and summer. These soils have fine-textured subsoils which exhibit moderate to high shrink-swell potentials. The productivity potential and erodibility of these units are considered moderate. The acreage estimate of the association is 591,737.

Terry Association (No. 12)

This unit is dominantly moderately deep but includes deep to shallow, well to excessively drained, loamy fine sand, sandy loam, and fine, sandy loam soils on nearly level to moderately steep uplands underlain with sandstone. These soils are moderately to highly erodible and have low productivity potentials. The acreage estimate for this association is 37,239.

Shingle-Kim-Shale Rock Outcrops Association (No. 13)

This unit consists of a narrow band of rolling, gullied uplands on shale-sandstone foothills and stream terraces. Shingle soils are shallow and located on the steeper slopes. Kim soils are on alluvial fans. Vegetative production is poor. A moderate to severe erosion hazard exists. The estimated acreage of the association is 240,425.

Renohill-Ulm-Olney-Arvada-Bone Association (No. 14)

This unit consists of deep and moderately deep, medium to fine-textured soils on level to gentle slopes developed in alluvium, derived from shales, sandstone, and alkaline shales. Renohill soils are fine textured and underlain by soft shale at a depth of 20 to 40 inches. Ulm soils are fine textured and underlain by soft shale below 40 inches in depth. Olney soils are medium textured and underlain by sandstone at depths below 40 inches. Arvada and Bone soils are deep, strongly saline, impervious to water, and occur as alkali panspots. The productivity potential is low and erodibility is high. The estimated acreage is 171,557.

Renohill-Pugsley-Briggsdale Association (No. 15)

This unit includes moderately deep, nearly level to steep soils on uplands, upland ridges, ridgecrests, and sidehill slopes. The Renohill and Briggsdale are derived from shale; Pugsley soils form from sandstone. These soils are highly erodible and have low to moderate productivity potentials. The estimated acreage of the association is 70,246.

Renohill-Briggsdale-Ulm-Tassel-Rock Outcrop Association (No. 16)

This unit includes shallow, moderately deep and deep silty clays, loams, clay loams, and sandy loams on gently sloping to very steep slopes and rock outcrops.

The Renohill, Briggsdale, and Tassel soils are situated on moderately steep to steep uplands. Ulm soils are found on nearly level to sloping alluvial fans. The Briggsdale and Ulm soils exhibit moderate to high shrink-swell potentials. The Ulm soils are subject to short periods of overflow. The productivity potential is low to moderate and erodibility is high. This association contains an estimated 138,538 acres.

Shingle-Tassel-Dwyer-Olney-Bowbac Association (No. 17)

This unit consists of shallow to deep, sandy to medium-textured soils on rolling to steeply rolling slopes, including upland ridges and sidehills dissected by numerous drainages.

The Shingle and Tassel soils are generally less than 20 inches deep over sandstone and shale bedrock. Olney soils are more than 40 inches deep to sandstone bedrock. Bowbac soils are 20 to 40 inches deep to bedrock. Hummocks and dune topography are associated with the deep, sandy Dwyer soils. This unit is subject to severe wind erosion hazards and is moderately erodible by water. The productivity potential is low to moderate. The acreage estimation for the association is 309,742.

Dwyer-Tassel-Terry Association (No. 18)

This unit consists of deep to shallow, sandy soils on rolling uplands dissected by drainages.

The Dwyer soils are loamy sands, deeper than 40 inches to bedrock. The Tassel soils are less than 20 inches deep to sandstone bedrock and have sandy loam textures. The Terry soils are 20 inches to 40 inches deep to bedrock and have sandy loam textures. This unit is subject to severe wind erosion and is moderately erodible by water. The productivity potential is low. The acreage estimate for this association is 74,712.

Rauzi-Renohill-Arvada Association (No. 19)

These are moderately deep and deep, fine loamy and fine soils on rolling, steep slopes over interbedded sandstone and shale.

This association of soils occurs on moderately sloping hills, ridges, and alluvial fans underlain by soft shale at shallow depths. The Rauzi soils are deep and medium textured, formed from sandstone and shale; Renohill soils are moderately deep and fine textured developing in shale; Arvada soils are deep and saline-alkali developing on alluvial deposits. The erosion hazard is severe and the productivity potential is low. The estimated acreage of this association is 307,800.

Tassel-Shingle-Terry-Olney-Bowbac Association (No. 20)

This unit consists of shallow, moderately deep and deep, moderately sandy and loamy soils developed from sandstone and shale and occupying rolling to steep topography with gentle to steep slopes dissected by many small drainages. The Tassel and Shingle soils are shallow and occur on the steeply sloping uplands. The Olney, Bowbac, and Terry soils occur on side and foot slopes. The productivity potential is moderate. These soils are subject to severe wind erosion and moderate water erosion. The estimated acreage of the association is 444,450.

Valent-Dwyer-Duneland Association (No. 21)

This association occurs on undulating to rolling, hummocky dune topography and is made up of deep aeolain sands and some active dunes. The soils are excessively drained, deep, loose sands. Wind erosion is severe and water erosion is moderate. Productivity potential is moderate. The estimated acreage of this association is 98,912.

WATER RESOURCES

Groundwater

The yield of water from a well is often expanded as the number of gallons per minute for each foot of drawdown in the well. A well that yields 10 gallons per minute for each foot of drawdown is said to have a specific capacity of 10. Specific capacity is greatly dependent upon the ease with which water will pass through the formation (transmissivity) and an estimate of well yield can be obtained from transmissivity. There are several "rules of thumb"for this calculation, one of which states that when transmissivity is reported in square feet per day (as it is in Table RB-2), the yield of the well in gallons per minute per foot of drawdown can be obtained by dividing the transmissivity value by 250. It is emphasized this is an estimate; in addition to being dependent on transmissivity, the specific capacity depends on other factors such as well construction and time of pumping.

VISUAL RESOURCES

Visual Resource Inventory and Evaluation Procedures

The evaluation process described below has been recently developed by the Bureau of Land Management (BLM). A complete explanation of the procedure with examples of various phases appears in BLM Manual 6300 entitled "Visual Resource Management"

The overall objective is to provide a Bureauwide systematic approach for identifying scenery quality and setting minimum quality standards for management of the visual resource values on public land. The process places all public land into one of five visual resource management classes. Each of these classes contains a specific management objective for maintaining or enhancing visual resource values. The visual management class assigned to a given land area depends upon three factors:

1. the inherent quality of the scenery being viewed
2. the visual sensitivity level (the type of visual use it receives)
3. the visual zone it is in

Scenic Quality

The process assigns a rating of: A—high scenic quality, B—moderate scenic quality, or C—low scenic quality to all lands within a given area, not just those administered by BLM. The procedure, as shown in Table RB-8, analyzes six key factors: landform, color, water, vegetation, uniqueness, and intrusions. Each of these factors is rated against a set of general criteria and a score assigned accordingly. When the evaluation is complete on a given land unit, the individual key factor scores are totaled and the letter rating A, B, or C is assigned, depending upon the total points received.

The scenery quality ratings for the Eastern Powder River Basin of Wyoming are described below.

Scenery Quality A. The only A quality scenery identified in the region is the North Platte River valley in Converse County. The river valley is a unique feature because it supports a relatively lush growth of grasses, shrubs, and cottonwoods in an area otherwise characterized by sparse vegetation. Also, the volume of stream flow is substantially greater than for any other stream in the region.

Scenery Quality B. There are B quality scenery areas scattered throughout the region, most of which are associated with either a ponderosa pine or juniper tree vegetative cover and/or a moderate topographic feature variety. Oil and gas development, utility lines, and roads are the main intrusions in this category.

Scenery Quality C. The region is predominately in the C rating category; the landforms, textures, and color are more muted than the areas in the B category. The characteristic landscape consists of open country with rolling plains, broad river courses, low hills, and scattered buttes. Water is rarely seen. There is no visually significant variation or contrast created by vegetation. The major intrusions are ranches with their related structures, highways and roads, transmission lines, water wells and reservoirs, oil and gas sites, coal mines and related structures, railroad lines, power plants, and farmland.

Visual Sensitivity Levels

Visual sensitivity levels are determined by people's concern for what they see. Criteria selected for analyzing sensitivity are: (1) use volumes of highway and transportation routes; (2) land use values (local and regional); (3) community attitude; and (4) other agency planning attitudes. These criteria and evaluation factors are listed in Table RB-9.

Use volume along Interstate 90 is estimated at 1,900 vehicles for average daily travel (ADT). Use of State Highway 59 between Gillette and the existing mining areas south of Gillette is estimated at 1,410 ADT. Use of State Highway 59 between the Campbell-Converse county line and Bill is estimated at 680 ADT. Use of State Highway 59 north of Gillette near Weston is estimated at 440 ADT. Use of U.S. Highway 14/16 northwest of Gillette is estimated at 530 ADT (Wyoming Highway Department 1976).

Land use values are considered to determine attitudes toward the use of land for mining versus historic uses of ranching and wildlife habitat. In Gillette and Douglas, the concern for such a change is rated low. Residents outside the immediate areas of Gillette and Douglas are more concerned about maintaining historic land uses with moderate economic growth, and preserving state water rights and wildlife habitat. They are expected to consider mining a moderate infringement upon other land use values.

Community attitude is based on concern for the "quality of life" that may exist in a booming mining community. Visual intrusions caused by mining may well cause concern about the appearance and planning of communities. Based upon the mix of residents (short-term and long-term), the matter is rated as being of moderate concern.

Agency planning attitudes are considered only for cities and counties, as state or federal lands are too small and scattered to reflect planning and development standards. In this category, local planning attitude for visual resources is considered moderate.

Overall the high sensitivity areas for managing visual resources lie within the heavily travelled zones along major highways and within the communities.

Visual Zones

Visual zones identify visible areas from key observation points (highways, well-traveled roads, overlooks, recreation sites) according to one of three types:

Foreground-Middleground. Foreground-middleground is described as the area visible from a travel route or observation point for a distance of 3 to 5 miles. The outer boundary of this zone is defined as the point where the

texture and form of individual plants are no longer apparent in the landscape.

Background. Background is described as the area beyond the foreground-middleground, usually from a minimum of 3 to 5 miles to a maximum of about 15 miles from a travel route or use area. Atmospheric conditions in some areas may limit the maximum to about 8 miles or increase it beyond 15 miles.

Seldom Seen. All areas not identified in the two previous zones are considered to be in the seldom seen zone. Generally, these are areas seen from low use transportation routes or beyond the 15-mile background zone for other routes.

Visual Resource Management Classes

Following identification of the three evaluation factors, all areas of common characteristics are mapped and labeled.

Using the matrix shown in Table RB-10, one of five visual resource management classes is then assigned to each of the units with common characteristics. For example, all areas in Class B scenery, high sensitivity level, and the background visual zone would be in Visual Resource Management Class III.

Each class describes a different degree of modification allowed by a managing agency in the basic elements of the landscape.

Class I. This class provides for natural ecological changes only. It is applied to primitive areas, some natural areas, and similar situations where activities are to be restricted.

Class II. Changes in any of the basic elements (form, line, color, or texture) should not be evident in the characteristic landscape.

Class III. Changes in the basic elements (form, line, color, or texture) may be evident in the characteristic landscape. However, the changes should remain subordinate to the visual strength of the existing character.

Class IV. Changes may subordinate the original composition and character, but must reflect what could be a natural occurrence within the characteristic landscape.

Class V. Intrusions overlying one of the management classes (I-IV) are significant enough to jeopardize effective management until the intrusions are removed.

Regional visual resource management classes are delineated on Map 9, Appendix A.

TABLE RB-1

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

Soil Series Assoc. Occurrence	Classification	Typical Text. of Surface Layer	Parent Material	Natural Soil Drainage Class	Depth of Rooting Zone (in)	Available Water Capacity (in)	Permeability Least Perm. Layer(in/hr)	Potential Frost Action	Shrink-Swell Potential	Hydro-logic Soil Group
Arvada 14, 19	Ustollic Natrargid fine, montmorillonitic, mesic	Fine sandy loam	Alluvium	Well drained	60"	5-6"	0.06"	Low	High	D
Bankard 1	Ustic Torrifluvent sandy, mixed calcareous mesic	Loamy fine sand	Sandy Alluvium	Somewhat excessively drained	60"	3-4"	6.0-20.0"	Moderate	Low	A
Bone 14	Ustic Torriorthent fine, montmorillontic, (calcareous) mesic	Loam	Alluvium	Moderately well drained	60"	4-5"	0.06"	Moderate to high	High	D
Bowbac 3,7, 17, 20	Ustollic Haplargids fine loamy, mixed mesic	Sandy Loam	Alluvial sediments from inter-bedded shale and sandstone	Well drained	30"	4-5"	0.6-2.0"	Moderate	Low to Moderate	B
Briggsdale 11, 15, 16	Ustollic Paleargid fine, montmorillonitic, mesic	Loam	Inter-bedded sandstone & shale	Well drained	30"	4-6"	0.2-0.6"	High	Moderate	C
Cushman 6, 9	Ustollic Haplargid fine-loamy, mixed mesic	Sandy loam	Inter-bedded shale & sandstone	Well drained	30"	5-7"	0.2-0.6"	Low	Moderate	C
Dwyer 17, 18, 21	Ustic Torripsamments mixed, mesic	Fine sand	Aeolian sand	Excessively drained	60"	3-4"	6.0-20.0"	Low	Low	A
Haverson 1	Ustic Torrifluvent fine-loamy mixed (calcareous) mesic	Loam	Strati-fied alluvium	Well drained	60"	6-10"	0.6-2.0"	Low	Low	B

TABLE RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

Soil Series Assoc. Occurrence	Classification	Typical Text. of Surface Layer	Parent Material	Natural Soil Drainage Class	Depth of Rooting Zone (in)	Available Water Capacity (in)	Permeability Least Perm. Layer(in/hr)	Potential Frost Action	Shrink-Swell Potential	Hydro-logic Soil Group
Kim 1, 13	Ustic Torriorthent fine-loamy, mixed (calcareous) mesic	Loam	Alluvium	Well drained	60"	10-12"	0.6-2.0"	Low	Low	B
Maysdorf 3	Ustollic Haplargid fine-loamy, mixed	Sandy Loam	Alluvial	Well drained	60"	7-9"	0.6-2.0"	Moderate	Low to	B
Olney 3, 7, 14, 17, 20	Ustollic Haplargids fine-loamy, mixed mesic	Sandy Loam	Alluvial sediments from inter-bedded shale and sandstone	Well drained	60"	6-9"	0.6-2.0"	High	Low to moderate	B
Pugsley 15	Ustollic Haplargid, fine-loamy, mixed mesic	Sandy Loam	Sandstone	Well drained	24"	2-4"	2.0-6.0"	Moderate	Low to moderate	B
Rauzi 19	Ustollic Haplargid, fine-loamy mixed mesic	Sandy Loam	Alluvial sediments from inter-bedded shale and sandstone	Well drained	60"	7-9"	0.6-2.0"	Moderate	Low to moderate	B
Razor 2	Ustollic Camborthid, fine, montmorillonitic, mesic	Silty clay loam	Shale	Well drained	24"	3-4"	.06-0.2"	Moderate	High	C
Renohill 3, 5, 6, 7, 8, 9, 10, 11, 15, 16, 19	Ustollic Haplargids fine montmorillonitic mesic	Clay Loam	Shale	Well drained	30"	5-6"	0.06-0.2"	High	High	C

TABLE RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

Soil Series Assoc. Occurrence	Erodibility	Inherent Fertility	Potential* Production (#/ac. dry wt)	Degrees of Limitation for and Soil Features Affecting: Land Capability Classification	Range Site	Final Cover for Mined Land: Inches Available	Final Cover for Mined Land: Suitability	Transportation Routes	Depth of Surface Layer (inches)	Soil Reaction (pH)	Salinity (mmhos/cm)
Ulm 3, 11, 14, 16	High	Medium	850-2000	IVe	Loamy	60"	Poor clay content	Severe, high frost action potential	3-6"	6.6-8.6	2
Valent 21	Very high wind erosion	Low	1000-2100	VIe	Sandy	60"	Poor	Slight- 8% slopes Moderate- 8-15% slopes Severe- 15% slopes	3-5"	7.9-8.4	0-4
Wibaux 7, 8	High	Low	450-1200	VIIs	Shallow loamy	15"	Poor, very gravelly	Severe, bedrock at 10-20" steep slopes	2-4"	7.8-8.6	<2
Wyarno 6	Medium	Medium	750-1800	IVs	Clayey	60"	Poor, clay content	Severe, high shrink-swell potential	3-7"	6.8-8.6	<2

TABLE RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

Soil Series Assoc. Occurrence	Degrees of Limitation for and Soil Features Affecting: Erodibility	Inherent Fertility	Potential* Production (#/ac. dry wt)	Land Capability Classification	Range Site	Final Cover for Mined Land: Inches Available	Final Cover for Mined Land: Suitability	Transportation Routes	Depth of Surface Layer (inches)	Soil Reaction (pH)	Salinity (mmhos/cm)
Haverson 1	High wind if cultivated Low water erosion	Medium	2000-3000	IVe	Lowland	60"	Fair to Good	Moderate flooding low strength	3-6"	7.9-8.4	0-4
Kim 1, 13	High	Medium	850-2000	IVe	Loamy	60"	Fair to Good	Moderate, 8%, severe, slopes 8%	6-9"	7.9-8.4	0-4
Maysdorf 3	Medium	Medium	1000-2100	VIe	Sandy	50"	Fair to Good	Moderate, moderate frost action	4-6"	6.6-8.4	<2
Olney 3, 7, 14, 17, 20	Medium	Medium to high	1000-2100	VIe	Sandy	50"	Fair to Good	Severe, frost action	2-4"	7.0-8.4	2-4
Pugsley 15	Medium	Medium	1000-2100	VIe	Sandy	24"	Fair	Moderate, bedrock at 20-40"	2-4"	6.6-7.3	<2
Rauzi 19	Medium	Medium	1000-2100	VIe	Sandy	60"	Fair	Moderate frost action	4-6"	6.6-7.0	<2
Razor 2	High	Low	750-1800	IVe	Clayey	30"	Poor, clay content	Severe, high shrink-swell potential	2-4"	8.2-8.6	2-4

TABLE RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

				Degrees of Limitation for and Soil Features Affecting							
Soil Series Assoc. Occurrence	Erodi-bility	Inherent Fertility	Potential* Production (#/ac. dry wt)	Land Capa-bility Classifi-cation	Range Site	Final Cover for Mined Land: Inches Available	Final Cover for Mined Land: Suitability	Transpor-tation Routes	Depth of Surface Layer (inches)	Soil Reaction (pH)	Salinity (mmhos/cm)
Renohill 3, 5, 6, 7, 8, 9, 10, 11, 15, 16, 19	High	Medium	750-1800	VIe	Clayey	25"	Poor, clay content	Severe, high shrink-swell potential	3-6"	7.0-8.6	<2
Samsil 2, 3, 5, 7, 8, 10, 13, 14, 17, 20	Very High	Medium	600-1100	VIIe	Shallow clayey	14"	Poor clayey shallow to bedrock	Severe, high shrink-swell potential	3-6"	7.4-9.0	0-4
Shingle 2, 3, 5, 7, 8, 10, 13, 17, 20	Very High	Low	450-1200	VIIe	Shallow loamy	18"	Poor, shallow depth to bedrock	Severe 4-15% slopes, low strength, Severe, 15-50% slopes, low strength and slope	3-6"	7.9-9.0	0-4
Tassel 8, 16, 17, 18, 20	Very high erosion	Low	600-1400	VIIe	Shallow sandy	18"	Poor sandy, shallow depth to bedrock	Severe, Bedrock at 10-20 inches	3-9"	7.9-8.4	0-4
Terry 5, 10, 12, 18, 20	High wind erosion	Low	1000-2100	VIe	Sandy	26"	Fair	Moderate, bedrock at 20-40"	4-6"	6.8-8.6	<2

TABLE RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

Soil Series Assoc. Occurrence	Classification	Typical Text. of Surface Layer	Parent Material	Natural Soil Drainage Class	Depth of Rooting Zone (in)	Available Water Capacity (in)	Permeability Least Perm. Layer(in/hr)	Potential Frost Action	Shrink-Swell Potential	Hydro-logic Soil Group
Samsil 2, 3, 5, 7, 8, 10, 13, 14, 17, 20	Ustic Torriorthents clayey, mixed, calcareous, mesic, thin	Clay	Shale	Well drained	14"	2-3"	0.06-0.2"	High	High	C
Shingle 2, 3, 5, 7, 8, 10, 13, 17, 20	Ustic Torriorthents loamy, mixed (cal-careous) mesic, shallow	Clay Loam	Inter-bedded sandstone, shale and loamstone	Well drained	15"	2-3"	0.2-0.6"	Low	Moderate	C
Tassel 8, 16, 17, 18, 20	Ustic Torriorthents loamy, mixed (cal-careous) mesic, shallow	Fine sandy loam	Soft sandstone	Well drained	15"	1-2"	2.0-6.0"	Low	Low	D
Terry 5, 10, 12, 18, 20	Ustollic Haplargid coarse-loamy, mixed, mesic	Fine sandy loam	Soft sandstone	Well drained	36"	4-5"	2.0-6.0"	Moderate	Low	C
Ulm 3, 11, 14, 16	Ustollic Haplargids fine, montmorillonitic, mesic	Loam	Inter-bedded shale & sandstone	Well drained	60"	10-12"	0.6-2.0"	High	Moderate to high	B
Valent 21	Ustic Torripsamments mixed, mesic	Loamy sand	Aeolian sand	Excessively drained	60"	3-5"	6.0-20.0"	Low	Low	A
Wibaux 7, 8	Ustic Torriorthent loamy-skeletal over gragmental, mixed, nonacid, mesic	Channery loam	Channery material over scoria beds	Well to what excess-ively drained	15"	2-3"	0.6-2.0"	Low	Low	D
Wyarno 6	Ustollic Haplargid, fine, montmorillonitic, mesic	Clay Loam	Alluvium from shales	Well drained	60"	10-12"	0.2-0.6"	Moderate	High	B

TABLE RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

Soil Series Assoc. Occurrence	Erodi-bility	Inherent Fertility	Potential* Production (#/ac. dry wt)	Land Capa-bility Classifi-cation	Range Site	Final Cover for Mined Land: Inches Available	Final Cover for Mined Land: Suitability	Transpor-tation Routes	Depth of Surface Layer (inches)	Soil Reaction (pH)	Salinity (mmhos/cm)
Arvada 14, 19	Very High	Low	1400-2200	VIs	Saline Lowland	60"	Poor, clay content alkali	Severe, high shrink-swell low strength	3-6"	7.4- 9.0	2-8
Bankard 1	Very High wind erosion	Low	2000-3000	IVe	Lowland	60"	Poor, sandy	Moderate, occasional flooding, moderate frost action	3-8"	7.9-8.4	2-8
Bone 14	Very High	Low	1400-2200	VIIs	Saline Lowland	60"	Poor, high clay content alkali	Severe, clay tex-ture, high shrink-swell	1"	9.2-9.6	2-8
Bowbac 3, 7, 17, 20	High Wind erosion	Medium	1000-2100	VIe	Sandy	30"	Fair, sandy loam	Moderate, bedrock at 20-40"	2-4"	7.0-8.4	2
Briggsdale 11, 15 16	High	Medium	850-2000	IVe	Loamy	36"	Poor-clay content	Severe, high frost action texture, plastic	3-8"	6.6-8.8	2
Cushman 6, 9	High	Medium	850-2000	VIe	Loamy	26"	Fair to good	Moderate low strength	1-3"	7.9-8.4	0-4
Dwyer 17, 18 21	Very high wind erosion	Low	1000-2100	VIe	Sandy	60"	Poor-sandy	Slight-slopes 8%, Moderate 8-15% slopes	4-8"	7.9-8.4	0-4

Degrees of Limitation for and Soil Features Affecting (spans columns from Land Capability to Salinity)

Table RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

*Low figure for unfavorable years, high figure for favorable years, normal years are average of high and low. Definitions applicable to the columns of the Soil Interpretations for Regional Soil Association Map.

Soil Series name and the distribution of the soil series within the different soil associations of the Powder River Basin study area.

Classification given is according to Soil Taxonomy for each series.

Typical texture of the surface refers to the relative proportions of the various size groups of individual soil grain, i.e. sands, silt, and clay.

Parent Material is the assumed geologic material the soil developed from.

Natural Soil Drainage Class is an expression of surface soil moisture relationships.

Depth of Rooting Zone is an indicator of the thickness plant roots can penetrate.

Available Water Capacity refers to the potential amount of water a soil can hold for plant use.

Permeability least Permeable layer is the rate at which water and air may move through the soil.

Potential Frost Action refers to the probable effects on structures results from the freezing of soil material.

Shrink-Swell Potential refers to the quality of a soil that determines its volume change resulting from wetting and drying.

Hydrologic Soil Groups are ranking of soils from A to D referring to runoff potential ranging from A, having the lowest rates to D with the highest rates.

Erodibility Class - The susceptibility of a soil to erosion when no cover is present. Rate of soil displacement is influenced primarily by soil qualities, physical properties, rainfall intensity, and slope gradient. Considered was each of six items listed within each of the three classes when classifying the area. Classes and rating items are as follows:

Class

Low - Potential erosion is not significant to reduce productivity.
- They contain water stable aggregates.
- They have good infiltration and percolation rates.
- They have adequate depth to store most of the normal precipitation.
- They contain no restrictive layers.
- They occur on gentle slopes.

Medium - Potential erosion is significant to reduce productivity but not to the point of entirely restricting production.
- They contain aggregates that are not water stable.
- They have moderate infiltration and percolation rates.
- They have moderate depths to store only part of the normal precipitation (AWC).
- They may contain restrictive layers.
- They occur on moderate slopes.

TABLE RB-1
(cont'd)

SOIL INTERPRETATIONS FOR REGIONAL SOIL ASSOCIATION MAP 4, APPENDIX A

High - Potential erosion will cause a reduction in productivity to practically zero.
- They contain very unstable aggregates.
- They have slow infiltration and percolation rates.
- They have little soil for water storage.
- They contain restrictive layers.
- They occur on steep slopes.

Where wind erosion is a hazard, it is mentioned specifically.

Inherent fertility - the following criteria were used for rating the soils:

Low — Soils low in available P or K, or with pH below 5.0 in the A and upper B horizons, or soils having levels of alkalinity or salinity such that choice of plants or growth of plants is severly limited.

Medium — Soils intermediate between low and high in inherent fertility.

High — Soils high in available P and K, with pH of 5.5 or more in A and upper B horizons, levels of salinity or alkalinity are sufficiently low that choices or growth of plants are not limited.

The degrees of limitation for Irrigation, Dwelling, and Transportation Routes are listed as slight, moderate or severe and give restrictive features if degree of limitation is other than slight. The definition of limitations are listed below.

Definition of Limitations

Slight soil limitation is the rating given soils that have properties favorable for the rated use. The degree of limitation is minor and can be overcome easily. Good performance and low maintenance can be expected.

Moderate soil limitation is the rating given soils that have properties moderately favorable for the rated use. This degree of limitation can be overcome or modified by special planning, design or maintenance. Some soils rated moderate require treatment such as artificial drainages, runoff control to reduce erosion, extended sewage absorption fields, extra excavation or some modification of certain features through manipulation of the soil.

Severe soil limitation is the rating given soils that have one or more properties unfavorable for the rated use such as steep slopes, bedrock near the surface, high shrink-swell potential, a seasonal high water table, flooding hazard or low bearing strength. This degree of limitation generally requires major soil reclamation, special design or intensive maintenance. Some of these soils, however, can be improved by reducing or removing the soil feature that limits use, but in most situations, it is difficult and costly to alter the soil or to design a structure so as to compensate for a severe degree of limitation.

Depth of surface layer (inches) refers to depth of darker colored A horizon in inches.

Soil reaction (pH) The degree of acidity or alkalinity of a soil expressed as a pH value. Descriptive terms commonly associated with certain ranges in pH are: slightly acid, 6.1-6.5; neutral, 6.6-7.3; slightly alkaline, 7.4-7.8; moderately alkaline 7.9-8.4; strongly alkaline, 8.5-9.0; and very strongly alkaline, 9.1.

Salinity (mmhos/cm) refers to the soluble salts in a soil, based on the electrical conductivity of the saturation extract, as expressed in millimhos per centimeter (mmhos/cm) at 25C.

Salinity Rating	mmhos/cm
Low	4
Moderate	4-8
High	8

TABLE RB-2

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING

CAMPBELL COUNTY

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fox Hills--Lance						
50-69-18 NE SW	Rozet #5	46	-	-	Sandstone	Company
Fort Union						
45-70-04 NW NW NW	CCR-3	32.08	-	-	Coal	Company
45-70-04 NW SE SE	CCR-2	1.34	-	-	Coal	Company
45-70-04 NW SE SE	CCR-2a	5.35	-	-	Coal	Company
46-70-18 NE NE NE	CCR-27	51.87	-	.000125	Coal	Company
46-70-18 NE NE NE	CCR-27a	61.76	-	-	Coal	Company
46-70-18 SW SW NE	CCR-24	343.58	-	-	Coal	Company
46-70-18 SE SE SE	CCR-21	401.07	-	-	Coal	Company
46-70-19 SW SW NE	CCR-17	1,470.59	-	-	Coal	Company
46-70-19 SW SW NE	CCR-17a	1,470.59	-	.000567	Coal	Company
46-70-19 SE SE SE	CCR-14	116.98	-	-	Coal	Company
46-70-19 SE SE SE	CCR-14a	110.29	-	.00050	Coal	Company

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING
CAMPBELL COUNTY (cont'd)

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fort Union (cont'd)						
46-70-19 SE SE SE	CCR-14c	155.75	-	.00146	Coal	Company
46-70-20 NE NE SW	CCR-18	22.73	-	-	Coal	Company
46-70-20 SW SW SW	CCR-14b	80.21	-	.00056	Coal	Company
46-70-27 SE SE NW	CCR-13	213.90	-	-	Coal	Company
46-70-28 NE NE NE	CCR-16	25.40	-	-	Coal	Company
46-70-29 NE NE SW	CCR-11	12.03	-	-	Coal	Company
46-70-29 SW SW SW	CCR-8	802.14	-	.000346	Coal	Company
46-70-29 SW SW SW	CCR-8a	815.51	-	-	Coal	Company
46-70-29 SE SE SE	CCR-9	110.29	-	-	Coal	Company
46-70-32 NW NW SE	CCR-5	306.15	-	-	Coal	Company
46-70-32 NW NW SE	CCR-5a	447.86	-	.000161	Coal	Company
46-70-33 SW SW NE	CCR-6	.40	-	-	Coal	Company
46-70-34 NW NW NW	CCR-10	362.30	-	-	Coal	Company
46-70-34 NE NE SW	CCR-7a	10,026.74	-	-	Coal	Company

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING
CAMPBELL COUNTY (cont'd)

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fort Union (cont'd)						
46-70-34 SW SW SW	CC-4a	11.76	-	-	-	Company
47-71-04 SW SE SE	-	1526.74	8.9	-	Coal	Company
48-71	-	295.72	-	-	Coal	Company
48-71-27 NW NW SE	WRRI-7	295.86	-	.0834	-	Company
50-71	EG40C-8	22.06	1.11	.0002	Coal	Company
50-71-05 SE SE NW	EG1-2	26.74	1.74	.35	Coal	Company
50-71-05 SE SE NW	EG6-AC	1.74	.016	.0014	Coal	Company
50-71-05 SE SE NW	EG6B	8.42	.08	.0012	Coal	Company
50-71-06 NE SW NW	EG4	14.17	.71	.000001	Coal	Company
50-71-06 SW SW SW	EG5C	1.60	.08	.00001	Coal	Company
50-71-17 NE NW NE	EG3-3	48.26	.48	.00078	Coal	Company
50-71-17 SE SE NW	EG9C	.67	.03	.00010	Coal	Company
50-71-17 SW SE SE	EG3-4	52.41	.52	.0012	Coal	Company

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING
CAMPBELL COUNTY (cont'd)

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fort Union (cont'd)						
50-71-21 NE SW SE	EG17C	9.89	.49	.01	Coal	Company
50-71-22 NE SW	Wyodak #7	108.29	3.88	.00009	Sandstone	USGS
50-71-27 NE NE NW	Wyodak #5	160.43	1.74	.00010	Sandstone	USGS
50-71-27 NW SW NW	Wyodak #6	128.34	1.87	.000075	Sandstone	USGS
50-71-29 SE NE	EG16AF	49.60	2.54	.00001	Sandstone	Company
50-71-29 SE NE	EG16AC	1,167	12.43	.33	Coal	Company
50-71-29 SE NE	EG16B	189.84	1.87	.0058	Coal	Company
50-71-29 SE NE	EG16C	189.84	1.87	.0058	Coal	Company
50-71-29 SW SE SW	EG18C	.13	.007	.001	Coal	Company
51-72-11 SW	-	15.37	-	.00020	Coal	Company
51-72-11 SW	-	41.44	-	.0030	Coal	Company
51-72-27	D305A	187.16	-	.00016	Coal	Company
52-72-32 SE NE	P-27	668.45	6.31	.00073	Coal	Company

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING
CAMPBELL COUNTY (cont'd)

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fort Union (cont'd)						
52-72-32 SE NE	P-27	1,229.95	11.60	.00049	Coal	Company
52-72-32 SE SW	CT-1	-	-	-	Coal	Company
52-72-32 SE SW	P-17	582.89	4.66	.00049	Coal	Company
52-72-32 SE SW	P-18	582.89	4.32	.0011	Coal	Company
52-72-32 SE SW	P-19	582.89	4.48	.0011	Coal	Company
Fort Union--Wasatch						
52-72-32 SE NE	CT-2	668.45	4.68	-	Sandstone and coal	Company
52-72-32 SE NE	P-26	855.61	5.82	.00073	Sandstone and coal	Company
52-72-32 SE NE	P-26	895.72	6.10	.00048	Sandstone and coal	Company
52-72-32 SE NE	P-29	788.77	5.63	.00047	Sandstone and coal	Company
52-72-32 SE NE	P-29	895.72	6.40	.00038	Sandstone and coal	Company

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING
CAMPBELL COUNTY (cont'd)

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fort Union--Wasatch (cont'd)						
52-72-32 SE NE	P-30	868.98	5.08	.00089	Sandstone and coal	Company
52-72-32 SE NE	P-30	895.72	5.24	.00085	Sandstone and coal	Company
Wasatch						
47-71-04 SW SE SE	-	53.48	.54	-	-	USGS
47-72-07	-	-	-	-	Coal	USGS
48-71-05 SE SE SE	Belle Ayr N-5	868.98	-	.00010	Sandstone	Company
50-71-29 SW SE SW	EG18W	5.08	.25	.003	Shale	Company
50-72-35 SE SE	-	91.84	-	-	Sandstone	Company
52-72-32 SE NE	P-28	962.57	19.25	.00073	Sandstone	Company
52-72-32 SE NE	P-28	1,229.95	24.60	.00058	Sandstone	Company
Alluvium						
51-72-05 NE NW	OT-2B	449.20	22.46	-	-	Company
51-72-05 NE NW	P-24	1,203.21	52.27	.060	-	Company
51-72-05 NE NW	P-25	1,336.90	66.84	.035	-	Company

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING

CROOK COUNTY

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Lance						
49-68-36 NW SE	-	22.73	.80	-	-	USGS
50-68-14 SE SW	-	141.7	3.48	-	-	USGS
50-68-24 SE SW	-	280.75	4.68	-	-	USGS
Fort Union						
49-68-16 NE SW	-	57.49	.69	-	-	USGS
49-68-27 SW NW	-	8.02	.07	-	-	USGS
49-68-28 NW NE	-	21.39	.80	-	-	USGS
49-68-29 SW NW	-	4.01	.07	-	-	USGS
Alluvium						
50-67-04 SW SW	-	1,470.59	77.54	-	-	USGS
50-67-05 SW SE	-	45.45	1.87	-	-	USGS
54-65-13 NE NW	-	2,754.0	81.55	-	-	USGS
55-64-32 NW SW	-	28.07	6.95	-	-	USGS

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING
SHERIDAN COUNTY

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fort Union						
54-84-05 NE SE	-	12.70	1.06	.00035	Sandstone	USGS
55-84-27 SW NW	-	1.34	.33	.000090	Sandstone	USGS
Wasatch						
54-81-14 SW NW	-	69.52	.87	.024	Coal	USGS
57-83-14 NE NW	-	294.11	-	-	Sandstone	USGS
Alluvium						
56-82-34 SW SE	-	1,297.0	51.0	-	-	USGS
57-85-19 NW NE	-	2,714.0	147.0	-	-	USGS
Spoil						
57-84-22 SE SW	-	22.99	.53	.233	-	SDSM*
57-85-01 NW SE	-	1,103.88	60.16	.128	-	SDSM

* South Dakota School of Mines (Rahn 1977)

TABLE RB-2
(cont'd)

AQUIFER TESTS IN THE FOX HILLS SANDSTONE, THE LANCE, FORT UNION, AND WASATCH FORMATIONS, AND THE ALLUVIUM IN THE POWDER RIVER BASIN OF WYOMING

JOHNSON COUNTY

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Wasatch						
51-82-33 SE SE	-	334.22	2.27	-	-	USGS

NATRONA COUNTY

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Fox Hills						
40-78-15 NW NE	-	213.90	-	.37	Sandstone	Wyoming State

NIOBRARA COUNTY

Location (Township, Range, Section)	Owner Number	Transmissivity (ft^2/day)	Conductivity (Permeability) (ft/day)	Storage	Lithology	Source of Data
Alluvium						
38-63-30 SE SW	-	4,411.76	-	-	-	USGS

TABLE RB-3

TYPICAL CLASSES OF ORGANIC COMPOUNDS
FOUND IN THE MAJOR AND MINOR FRACTIONS

Major/Minor Fractions	Hydrophobic	Hydrophillic
Acid	Aliphatic acids <5 carbons, aromatic acids, and high molecular weight phenols.	Polyfunctional acids, carboxylic and dicarboxylic acids, and hydroxy acids.
Basic	Aromatic bases.	Polyfunctional aliphatic bases.
Neutral	High molecular weight hydrocarbons, polynuclear aromatics, and high molecular weight alcohols, aldehydes, ketones, amides, and nitriles.	Polyfunctional and lower molecular weight alcohols, aldehydes, ketones, amides, and nitriles.

Source: Reports of U.S. Geological Survey

TABLE RB-4

DISSOLVED ORGANIC CARBON FRACTIONS FOUND IN WATER
IN CAMPBELL COUNTY, WYOMING
Results in mg/l

HYDROPHOBIC

Station Number	Acid	Base	Neutral
1	1.3	<0.1	0.3
2	1.5	<0.1	0.3
3	2.8	<0.1	0.8
4	2.6	<0.1	1.4

HYDROPHILLIC

Station Number	Acid	Base	Neutral
1	1.0	0.1	0.4
2	2.0	0.2	0.3
3	4.0	0.3	0.5
4	2.7	0.3	0.3

Source: Reports of U.S. Geological Survey

TABLE RB-5
STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

Station Number* and Type	Station Name	Drainage Area (sq. mi.)	Records Available (years)	Annual Mean Discharge (cfs) Average	Annual Mean Discharge (cfs) Range	Range of Annual Minimum Daily Discharge (cfs)
06312910 S-R	Dead Horse Creek tributary near Midwest	1.53	1965-72	-	-	0-0
06312920 S-R	Dead Horse Creek tributary No. 2 near Midwest	1.34	1965-72	-	-	0-0
06313000 C	South Fork Powder River near Kaycee	1,150	1938-40, 1950-69	36.2	10.5-109	0-4.6
06313020 S-R	Bobcat Creek near Edgerton	8.29	1965-73	-	-	0-0
06313050 S-R	East Teapot Creek near Edgerton	5.44	1965-72	-	-	0-0
06313100 C-S	Coal Draw near Midwest	11.4	1961-	-	-	0-0
06313180 S-R	Dugout Creek tributary near Midwest	.71	1965-73	-	-	0-0
06313200 C-S	Hay Draw near Midwest	1.60	1958-70	-	-	0-0
06313700 C-S, C	Dead Horse Creek near Buffalo	155	C-S 1958-71, C 1971-	-	-	0-0
06316480 S-R	Headgate Draw at upper station near Buffalo	3.32	1965-73	-	-	0-0

TABLE RB-5
(cont'd)
STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

Station Number* and Type	Station Name	Drainage Area (sq. mi.)	Records Available (years)	Annual Mean Discharge (cfs) Average	Annual Mean Discharge (cfs) Range	Range of Annual Minimum Daily Discharge (cfs)
06379600 C, C-S	Box Creek near Bill	112	C 1956-58, C-S 1959-	-	-	0-0
06382200 S-R	Pritchard Draw near Lance Creek	5.1	1965-	-	-	0-0
06386000 C	Lance Creek at Spencer	2,070	1948-54, 1956-	26.3	2.74-73.9	0-0
06386500 C	Cheyenne River near Spencer	5,270	1948-	59.4	5.95-283	0-0
06426000 C	Belle Fourche River near Moorcroft	1,380	1923-33	67.8	3.0-244	0-.3
06426200 C-S	Donkey Creek tributary near Gillette	.28	1960-	-	-	0-0
06426500 C	Belle Fourche River below Moorcroft	1,670	1924-70	21.0	1.14-104	0-0
06644840 S-R	McKenzie Draw tributary near Casper	2.02	1965-73	-	-	0-0
06648720 S-R	Frank Draw tributary near Orpha	.79	1965-73	-	-	0-0
06648780 S-R	Sage Creek tributary near Orpha	1.38	1965-73	-	-	0-0

TABLE RB-5
(cont'd)
STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

Station Number* and Type	Station Name	Drainage Area (sq. mi.)	Records Available (years)	Annual Mean Discharge (cfs)		Range of Annual Minimum Daily Discharge (cfs)
				Average	Range	
06316700 S-R	Powder River tributary near Buffalo	1.64	1965-73	-	-	0-0
06317000 C	Powder River at Arvada	6,050	1930-33, 1934-	272	70.3-668	0-24
06317050 C-S	Spotted Horse Creek tributary near Spotted Horse	4.28	1961-	-	-	0-0
06324800 C-S	Little Powder River tributary near Gillette	.81	1960-	-	-	0-0
06324810 S-R	Box Draw tributary near Gillette	.5	1965-72	-	-	0-0
06324900 C-S	Little Powder River tributary No. 2 near Gillette	3.95	1959-	-	-	0-0
06325000 C	Little Powder River at Biddle, Montana	1,541	1938-43	-	20.5-30.2	0-0
06334000 C	Little Missouri River near Alzada	904	1911-25, 1928-32, 1935-69	77.2	1.92-324	0-.1
06363700 C-S	Porcupine Creek near Turnercrest	31.5	1959-	-	-	0-0
06378640 C-S	Lance Creek tributary near Lance Creek	1.2	1965-	-	-	0-0

TABLE RB-5
(cont'd)
STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

Station Number* and Type	Station Name	PEAK FLOWS: Average Recurrence Interval (years) 2	5	10	25	50	Maximum Observed: Date	Discharge (cfs)	Unit Discharge (cfs/sq mi)	Factors Affecting Natural Flow
06312910 S-R	Dead Horse Creek tributary near Midwest	388	1,130	2,170	-	-	6-20-69	3,020	2,000	
06312920 S-R	Dead Horse Creek tributary No. 2 near Midwest	226	550	922	-	-	6-4-72	1,470	1,100	
06313000 C	South Fork Powder River near Kaycee	2,630	8,150	14,900	28,600	43,800	5-22-62	35,500	30.9	
06313020 S-R	Bobcat Creek near Edgerton	24	260	850	-	-	9-11-73	1,070	129	
06313050 S-R	East Teapot Creek near Edgerton	320	1,300	2,700	-	-	6-10-65	4,450	818	
06313100 C-S	Coal Draw near Midwest	696	1,900	2,730	-	-	6-22-64	2,620	230	
06313180 S-R	Dugout Creek tributary near Midwest	251	635	1,050	-	-	7-15-67	1,590	2,239	
06313200 C-S	Hay Draw near Midwest	300	634	920	1,350	-	7-15-67	900	562	
06313700 C-S, C	Dead Horse Creek near Buffalo	822	1,560	2,040	2,600	-	5-26-62	2,300	14.8	
06316480 S-R	Headgate Draw at upper station near Buffalo	200	1,900	4,600	-	-	6-15-65	5,490	1,650	

TABLE RB-5
(cont'd)
STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

Station Number* and Type	Station Name	PEAK FLOWS: Average Recurrence Interval (years) 2	5	10	25	50	Maximum Observed: Date	Discharge (cfs)	Unit Discharge (cfs/sq mi)	Factors Affecting Natural Flow
06316700 S-R	Powder River tributary near Buffalo	258	1,100	2,250	-	-	6-16-65	2,290	1,400	
06317000 C	Powder River at Arvada	7,330	14,700	22,200	36,000	50,500	9-29-23	100,000	16.5	Irrigation diversions, numerous reservoirs.
06317050 C-S	Spotted Horse Creek tributary near Spotted Horse	91	412	985	2,660	-	6-13-62	3,120	729	
06324800 C-S	Little Powder River tributary near Gillette	-	-	-	-	-	6-22-64	176	218	
06324810 S-R	Box Draw tributary near Gillette	10	60	150	-	-	5-22-68	84	168	
06324900 C-S	Little Powder River tributary No. 2 near Gillette	168	350	502	725	-	6-22-64	758	192	
06325000 C	Little Powder River at Biddle, Montana	0	0	0	0	0	8-17-40	5,700	3.70	Small diversions for irrigation of hay meadows above station
06334000 C	Little Missouri River near Alzada, Montana	1,940	3,350	4,220	5,210	5,860	4-4-44	6,000	6.64	Do.
06363700 C-S	Procupine Creek near Turnercrest	-	-	-	-	-	6-15-62	1,230	39.0	

TABLE RB-5
(cont'd)
STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

Station Number* and Type	Station Name	PEAK FLOWS: Average Recurrence Interval (years) 2	5	10	25	50	Maximum Observed: Date	Discharge (cfs)	Unit Discharge (cfs/sq mi)	Factors Affecting Natural Flow
06378640 C-S	Lance Creek tributary near Lance Creek	60	331	744	-	-	9-3-68	1,060	883	
06379600 C, C-S	Box Creek near Bill	145	692	1,560	3,660	-	5-5-71	1,720	15.4	
06382200 S-R	Pritchard Draw near Lance Creek	763	2,140	3,420	-	-	9-3-68	4,050	794	
06386000 C	Lance Creek at Spencer	1,970	3,600	4,790	6,340	7,500	5-24-71	7,410	3.58	Numerous small reservoirs, diversions for irrigation of 3,500 acres.
06386500 C	Cheyenne River near Spencer	3,160	6,620	9,820	15,000	19,900	5-27-62	16,000	3.04	Numerous small reservoirs, diversions for irrigation of 6,860 acres.
06426000 C	Belle Fourche River near Moorcroft	2,000	7,000	11,000	-	-	4-7-24	12,500	9.06	Numerous small reservoirs, diversions for irrigation.
06426200 C-S	Donkey Creek tributary near Gillette	34	57	84	137	-	7-22-66	165	589	
06426500 C	Belle Fourche River below Moorcroft	898	2,040	3,050	4,600	5,950	4-7-24	12,500	7.49	Numerous small reservoirs, diversions for irrigation.

TABLE RB-5
(cont'd)
STREAMFLOW CHARACTERISTICS AT GAGING STATIONS

Station Number* and Type	Station Name	PEAK FLOWS: Average Recurrence Interval (years) 2	5	10	25	50	Maximum Observed: Date	Discharge (cfs)	Unit Discharge (cfs/sq mi)	Factors Affecting Natural Flow
06644840 S-R	McKenzie Draw tributary near Casper	32	212	540	-	-	9- -73	970	480	
06648720 S-R	Frank Draw tributary near Orpha	50	212	408	-	-	8-19-66	342	433	
06648780 S-R	Sage Creek tributary near Orpha	22	94	181	-	-	7-25-65	229	166	

Source: Reports of the U.S. Geological Survey

* Refer to Figure R2-16.

C: continuous record gaging station.

C-S: partial-record gage for determining peak flows.

S-R: partial-record gage for determining rainfall-runoff relations.

TABLE RB-6
SUSPENDED SEDIMENT DATA

Station Number*	Station Name	Period of Record	Observed Daily Values: Date	Flow (cfs)	Maximum Concentration (mg/l)	Date	Flow (cfs)	Maximum Load (tons/day)
06313100	South Fork Powder River near Kaycee	1950-53	9/7/51	852	94,800	5/22/52	4,260	1,270,000
06313500	Powder River at Sussex	1950-53	8/3/53	1,090	87,500	5/23/52	14,100	2,850,000
06317000	Powder River at Arvada	1947-57 1968	7/19/54	792	113,000	5/24/52	12,500	2,340,000
06334000	Little Missouri River near Alzada, Montana	1949-52	5/21/49	57	20,300	5/10/50	1,180	17,600
06386000	Lance Creek near Spencer	1950-54, 1957-59	7/19/54	74	57,700	6/27/52	3,620	281,000
06394000	Beaver Creek near Newcastle	1949-57	5/22/57	134	36,000	5/25/57	780	90,800
06426500	Belle Fourche River below Moorcroft	1947-52	---	-	-	9/5/51	710	12,400

Source: Reports of the U.S. Geological Survey.

* Refer to Figure R2-16.

TABLE RB-7
CHEMICAL QUALITY DATA

Station Number	Station Name	Period of Record (month/year)	Dissolved Calcium (Ca) (mg/l) Max	Min	Dissolved Magnesium (Mg) (mg/l) Max	Min	Dissolved Sodium (Na) (mg/l) Max	Min	Dissolved Bicarbonate (HCO_3) (mg/l) Max	Min	Dissolved Sulfate (SO_4) (mg/l) Max	Min	Dissolved Solids (mg/l) Max	Min	Temperature (Degrees C.) Max	Min
06313400	Salt Creek near Sussex, Wyoming	10/67 to	582	23	179	6.8	2,000	82	1,410	172	1,900	76	5,660	2,640	31.0	.0
	(sampled about monthly)	09/75	0.1*	25*	9.0*	0.1*	12*	11*	12*	0.1*	26*	18*	26*	137*	16*	9.1-46*
06324830	Rawhide Creek** at U.S. Highway	03/75 to	400	390	490	470	685	650	638	334	4,000	780	5,890	1,410	25.0	20.3
	14/16 Wy. (3 samples)	08/76	-*	.18*	-*	.18*	-*	-*	-*	6.7*	9.6*	1.0*	.18*	6.7*	.18*	6.7*
06324890	Little Powder River** below Corral Creek,	06/75 to	420	330	190	150	150	130	296	280	1,900	1,500	2,890	2,310	24.0	4.0
	Wy. (3 samples)	11/76	9.6*	1.0*	9.6*	1.0*	9.6*	1.0*	9.6*	1.0*	9.6*	1.0*	9.6*	1.0*	.73*	1.0*
06324912	Little Powder River** above Cottonwood	06/75 to	410***		190***		150***		297***		1,900***		2,800***		21.5	5.5
	Creek, Wy (3 samples)	11/76	5.2*		5.2*		5.2*		5.2*		5.2*		5.2*		5.2*	-*
06324925	Little Powder River** near Weston,Wy. (1	06/75	190***		110***		340***		453***		1,200***		2,090***			18.0***
	sample)		2.1*		2.1*		2.1*		2.1*		2.1*		2.1*			2.1*
06324970	Little Powder River** above Dry Creek near	06/75 to	320	46	180	23	590	100	633	112	2,100	340	3,440	621	27.0	.0
	Weston, Wy. (53 samples)	06/77	1.4*	16*	1.4*	16*	.31*	16*	6.0*	16*	.02*	5.4*	.02*	5.4*	.00	.5-17*

TABLE RB-7
(cont'd)
CHEMICAL QUALITY DATA

Station Number	Station Name	Period of Record (month/year)	Dissolved Calcium (Ca) (mg/l) Max	Min	Dissolved Magnesium (Mg) (mg/l) Max	Min	Dissolved Sodium (Na) (mg/l) Max	Min	Dissolved Bicarbonate (HCO_3) (mg/l) Max	Min	Dissolved Sulfate (SO_4) (mg/l) Max	Min	Dissolved Solids (mg/l) Max	Min	Temperature (Degrees C.) Max	Min
06324985	Little Powder River**	05/69	258	56	162	30	805	151	732	166	2,410	445	4,050	791	26.0	.0
	near Wyo-Montana	to														
	line (7 samples)	05/70	.55*	17*	.55*	17*	.55*	9.2*	.55*	55*	.55*	17*	.55*	17*	.40*	.55*
06365300	Dry Fork Cheyenne**	05/77	190***		94***		90***		400***		620***		1,220***		22.5	16.0
	River near Bill, Wy.															
	(2 samples)		.30*		.30*		.30*		.30*		.30*		.30*		.05*	.30*
06365900	Cheyenne River**	11/75	400	150	200	57	500	130	643	214	2,300	700	3,810	1,180	28.0	.0
	near Dull Center, Wy.	to														
	(sampled about	05/77	.30*	5.7*	.30*	5.7*	.30*	5.7*	.30*	5.7*	.30*	5.7*	.30*	5.7*	4.0*	.30*
	monthly)															
06386500	Cheyenne River**	2-6/70	222	110	82	50	541	250	351	209	1,660	740	2,760	1,320	23	6.0
	near Spencer, Wy.	7-8/75	3.8*	2.0*	.25*	1.2*	.25*	20*	7.6*	.25*	.25*	20*	.25*	20*	20*	7.6*
	(sampled about															
	monthly)	5-8/69											3,280	1,090	30	16
06425720	Belle Fourche**	10/75	530	310	530	160	1,200	350	410	222	5,400	1,900	7,870	2,900	25.0	.0
	River below Rattle-	to														
	snake Creek near	05/77	.00*	.10*	.00*	.10-1.0*	.00*	.10*	.05*	.05*	.00*	.10*	.00*	.10*	.00*	1.0*
	Big Piney (sampled															
	about monthly)															
06425780	Belle Fourche**	10/75	380	63	210	26	470	64	386	98	2,400	300	3,690	517	32.0	.0
	River above Dry	to														
	Creek near Big	05/77	.05*	1.0*	.05*	1.0*	.05*	1.0*	.02*	1.0*	.05*	1.0*	.05*	1.0*	.01*	.05*
	Piney, Wy. (sampled															
	about monthly)															
06426500	Belle Fourche**	08/54														
	River below	to											2,910	162		
	Moorcroft, Wy.	09/57														
	(sampled period-												0.3*	132*		
	ically)	7-9/75	59	30	50	23	580	100	657	169	1,000	260	2,050	544	31	27
	(sampled monthly)		.05*	.10*	.10*	3.4*	.05*	3.4*	.05*	3.4*	.05*	3.4*	.05*	3.4*	.05*	.10

Source: Reports of the U.S. Geological Survey.

Note: Refer to Figure R2-16 for station locations.

* Streamflow discharge in cfs (cubic feet per second).
** Other analyses, trace metals, biological data, coliform, field tests of dissolved oxygen, and more are available in various reports of U.S. Geological Survey.
*** Only one value.

KEY FACTORS	RATING CRITERIA AND SCORE		
① LAND FORM	Vertical or near vertical cliffs, spires, highly eroded formations, massive rock outcrops, severe surface variation. 4	Steep canyon walls, mesas, interesting erosional patterns, variety in size and shape of land forms. 2	Rolling hills, foothills, flat valley bottoms. 1
② COLOR	Rich color combinations, variety or vivid contrasts in the color of soil, rock, vegetation, or water. 4	Some variety in colors and contrast of the soil, rock and vegetation, but not dominant. 2	Subtle color variation, little contrast, generally muted tones. Nothing really eye-catching. 1
③ WATER	Still, chance for reflections or cascading white water, a dominant factor in the landscape. 4	Moving and in view or still but not dominant. 2	Absent, or present but seldom seen. 1
④ VEGETATION	A harmonious variation in form, texture, pattern, and type. 4	Some variation in pattern and texture, but only one or two major types. 2	Little or no variation, contrast lacking. 1
⑤ UNIQUENESS	One of a kind or very rare within region. 6	Unusual but similar to others within the region. 2	Interesting in its setting, but fairly common within the region. 1
⑥ INTRUSIONS	Free from aesthetically undesirable or discordant sights and influences. 2	Scenic quality is somewhat depreciated by inharmonious intrusions but not so extensive that the scenic qualities are entirely negated. 1	Intrusions are so extensive that scenic qualities are for the most part nullified. -4
Scenery A = 15 - 24 Scenery B = 10 - 14 Scenery C = 1 - 9			

EXPLANATION OF RATING CRITERIA

① Land Form or topography becomes interesting as it gets steeper and more massive. Examples of outstanding land forms are found in the Grand Canyon, the Sawtooth Mountain Range in Idaho, the Wrangle Mountain Range in Alaska, and the Rocky Mountain National Park.

② Color Consider the overall color of the basic components of the landscape (i.e., soil, rocks, vegetation, etc.) as they appear during the high-use season. Key factors to consider in rating "color" are variety, contrast, and harmony.

③ Water is the ingredient which adds movement or serenity to a scene. The degree to which water dominates the scene is the primary consideration in selecting the rating score.

④ Vegetation Give primary consideration to the variety of patterns, forms, and the texture created by the vegetation.

⑤ Uniqueness This factor provides an opportunity to give added importance to one or all of the scenic features that appear to be relatively unique within any one physiographic region. There may also be cases where a separate evaluation of each of the key factors does not give a true picture of the overall scenic quality of an area. Often it is a number of not so spectacular elements in the proper combination that produces the most pleasing scenery - the uniqueness factor can be used to recognize this type of area and give it the added emphasis it needs.

⑥ Intrusions Consider the impact of man-made improvements on the aesthetic quality. These intrusions can have a positive or negative aesthetic impact. Rate accordingly.

Table RB-8

SCENIC QUALITY RATING PROCEDURE

TABLE RB-9

CRITERIA FOR DETERMINING SENSITIVITY LEVEL

Criteria	High	Medium	Low
Use volume (Total use, no distinction between types)	More than 200 vehicles per day	20-200 vehicles per day	Less than 20 vehicles per day
Land use values			
Gillette and Douglas	Major	Secondary	Minor
Regional	Major	Secondary	Minor
Community attitude	Major	Secondary	Minor
Agency planning attitude	Major	Secondary	Minor

RECREATION RESOURCES

VISITOR USE STATISTICS

Bighorn National Forest	Increase (+) or Decrease (-) Over Previous Year
1972 - 1,135,800 Visitor Days	
1973 - 1,061,700	(-6.5%)
1974 - 981,000	(-7.6%)
1975 - 1,117,000	(+13.9%)
1976 - 1,244,500	(+11.4%)

Black Hills National Forest	
1970 - 1,765,000 Visitor Days	
1971 - 1,851,400	(+4.9%)
1972 - 1,632,000	(-11.9%)
1973 - 1,639,700	(+0.5%)
1974 - 1,501,300	(-8.4%)
1975 - 1,581,000	(+5.3%)
1976 - 2,306,500	(+45.9%)

Medicine Bow National Forest (Laramie Peak Ranger District)

1976 - 59,500 Visitor Days

1977 - Based on spring use, visitor use could reach 85,000+ visitor days.

Thunder Basin National Grasslands	1974 Recreation Use
Activity	Visitor Days
Auto Pleasure Driving	5,500
Motorcycle Driving	700
Horseback Riding	400
Snowcraft	1,200
Fishing	2,900
Camping	900
Picnicking	1,300
Hunting	12,000

The U.S. Forest Service estimates that visitation to the grasslands for 1976 is approximately the same as that reported for 1974. Forest Service statistics obtained by personal communication 1977.

Devils Tower National Monument	Increase (+) or Decrease (-) Over Previous Year
1970 - 147,444 Visitors	
1971 - 138,372	(-6.2%)
1972 - 149,306	(+7.9%)
1973 - 153,200	(+2.6%)
1974 - 125,592	(-18.0%)
1975 - 151,566	(+20.7%)
1976 - 169,754	(+12.0%)

Source: Personal communication, Wonder 1977

Wyoming State Parks Visitation

	Glendo	Guernsey	Keyhole
1975	117,449 Visitors	82,583 Visitors	65,908 Visitors
1976	117,881 (+.4%)	79,847 (-3.3%)	100,049 (+51.8%)

Source: Wyoming Recreation Commission 1976

		2/ VISUAL SENSITIVITY LEVEL						
		HIGH			MEDIUM			LOW
SPECIAL AREAS		I	I	I	I	I	I	I
1/ SCENERY CLASS	A	II	II	II	II	II	II	II
	B	II	III	IV	III	IV	IV	IV
	C	III	IV	IV	IV	IV	IV	IV
		FG	BG	SS	FG	BG	SS	SS
		3/ VISUAL ZONES						

1/ SCENERY QUALITY INVENTORY (6310.11) — A, B, C

2/ VISUAL SENSITIVITY LEVEL (6310.12) — High, Medium, Low

3/ VISUAL ZONES (6310.13) — FG - Foreground - Middleground; BG - Background; SS - Seldom Seen

NOTE: Class I applies only to classified special areas, e.g., Wilderness, Primitive, Natural Areas, etc. This quality standard is established through legislation or policy.

Class V applies to areas identified in the scenery quality inventory where the quality class has been reduced because of unacceptable intrusions.

Table RB-10

VISUAL RESOURCE MANAGEMENT CLASS DETERMINATION

APPENDIX C

GLOSSARY

ACRE-FOOT. A term used in measuring the volume of water, equal to the quantity required to cover 1 acre to a depth of 1 foot, or 43,560 cubic feet.

ALBEDO. The ratio of the amount of electromagnetic radiation reflected by a body to the amount incident upon it.

ALLUVIAL TERRACE. Alluvium deposited in a narrow, relatively level band along the course of a stream, marking a former water level.

ALLUVIUM. Clay, silt, sand, gravel, or other rock material transported by flowing water and deposited as sediment.

AMBIENT CONCENTRATION. The ground-level pollutant concentration resulting from all sources, man-made or natural.

ANIMAL UNIT MONTHS. A measure of the forage or feed required to maintain one animal unit (a cow, a horse, or five sheep) for 1 month (30 days).

AQUIFER. A body of rock that is saturated with and conducts groundwater; a water-bearing formation that yields water to wells or springs.

ARTESIAN FLOW. The discharge of water from a well or spring by artesian pressure or hydrostatic pressure within a confined aquifer. A confined aquifer is one surrounded by less permeable rock layers.

CARRYING CAPACITY. The maximum number of all animals that an area can support during a given period of the year.

CATION-EXCHANGE SOFTENING. The natural exchange of calcium and magnesium ions in water for the sodium ions in clay. A similar exchange process occurs in household water softeners.

CLASS A PAN EVAPORATION RATE. The rate at which water evaporates into the atmosphere from a cylindrical pan 48 inches in diameter and 10 inches deep.

CLOSED-CANOPY FOREST. A forest in which the leaves and branches at the tops of the trees touch.

COLIFORM COUNT. The number of colonies of coliform bacteria in a given volume; an indication of the fecal contamination of water. Coliform bacteria inhabit the colons of warm-blooded animals.

COMMUNITY. An aggregation of organisms (plant or animal) within a specific area.

CONE OF DEPRESSION. A depression in the potentiometric surface of a body of groundwater. It develops around a well from which water is withdrawn or around a mine which intercepts an aquifer.

CRITICAL (OR CRUCIAL) WILDLIFE HABITAT. That portion of the habitat of a wildlife species that is essential to the survivial and perpetuation of that species, either as a population or as individuals.

DENDRITIC DRAINAGE PATTERN. A drainage pattern in which streams branch irregularly in all directions, resembling the branching pattern of trees.

DISCHARGE (GROUNDWATER). The removal of water from an aquifer.

DRAWDOWN. The difference between the static water level in an aquifer and that resulting from removal of water from the aquifer.

EPHEMERAL STREAM. A stream which flows only in response to precipitation or snowmelt.

EVAPOTRANSPIRATION RATE. The rate at which water is lost from the land area through transpiration of plants and evaporation from the soil.

FAULT. A zone of rock fracture along which there has been displacement.

FUGITIVE DUST. Dust particles made airborne by wind or man's activities. Common sources include unpaved roads, construction sites, and tilled land.

HEADCUTTING (SCALPING). An upvalley movement of a stream gully as flowing water cuts or erodes soil into the channel. The gully resulting from headcutting is so deep it cannot be crossed by wheeled vehicles or eliminated by plowing.

HORIZON (SOIL). A layer of soil, approximately parallel to the surface, that has characteristics of color, structure, or texture distinct from other layers.

INFILTRATION RATE. The rate at which soil can absorb falling rain or melting snow.

INTERMITTENT STREAM. A stream which flows only part of each year.

ISOPLETH. A line on a map connecting points at which a given variable, such as air pollutant concentration, has a constant value.

LAKE EVAPORATION. The amount of water which evaporates from a body of water during a given period of time.

LEACHATE. A solution obtained by leaching.

LEACHING. The removal in solution of soluble constituents (such as mineral salts or organic matter) from an upper to a lower soil or rock layer by water draining through them.

LENTICULAR FORMATION. A lens-shaped body of rock, thick in the middle and thinning toward the edges.

LIMITING FACTOR. The living or nonliving factor of the environment which is in least supply and which is critical to survivial of a plant or animal.

LITHIC MATERIAL. Any stone material worked by man--flakes, tools, or debitage from tool production and maintenance.

LITHOLOGY. The physical character of rock.

"MAJOR" STATIONARY SOURCE. A facility which has uncontrolled emissions greater than 250 tons per year of any criteria pollutant, or greater than 100 tons per year of sulfur dioxide or particulates.

MIXING HEIGHT. The height above the ground below which turbulence causes the air to be well mixed.

ORGANIC COMPOUND. A compound containing carbon, especially in which hydrogen is attached to carbon.

ORGANIC MATTER. Any material derived from living things, as opposed to mineral or inorganic matter. The organic matter in soil consists primarily of the remains of plants.

OXIDATION. The process by which a chemical is changed by combining it with oxygen, or by increasing the proportion of its electronegative parts.

PARENT MATERIAL. The unconsolidated, weathered mineral or organic material from which soil develops.

PARTING. A band of waste material, such as shale, which divides layers of coal.

PERCHED GROUNDWATER. Groundwater perched on an impermeable rock lens and separated from an underlying body of groundwater by unsaturated rock.

PERENNIAL STREAM. A stream that flows continuously throughout the year.

PERMEABILITY. The capacity of a porous rock or sediment for transmitting fluid.

PERMEABILITY RATE (SOIL). The rate at which water passes through a layer of soil.

pH. An expression of acidity or alkalinity, measured on a scale of 0 through 14, on which 7 represents neutrality. Values less than 7 represent increasing hydrogen ion concentration (increasing acidity). Values greater than 7 represent decreasing hydrogen ion concentration (increasing alkalinity).

PHOTOCHEMICAL OXIDANT. A secondary pollutant formed in a photochemical reaction involving hydrocarbons and oxides of nitrogen.

PICOCURIE. One trillionth of one curie. A curie is a measure of radioactivity equal to 3.7×10^{10} disintegrations per second.

PLAYA. A shallow, completely closed (undrained) basin where water collects (as after a rain) and quickly evaporates, often leaving deposits of soluble salts.

POINT-WATERING SOURCE. A pool in the bed of an intermittent stream, or any spring, well, or stockpond where livestock and wildlife can obtain water.

POTENTIOMETRIC SURFACE. An imaginery surface representing the static head of groundwater and defined by the level to which water will rise in a well. The water table is a particular potentiometric surface.

PREFERENCE RIGHT COAL LEASE APPLICATION. An application for a federal coal lease for which the applicant has established a preferential or first right through his initiative in prospecting for and demonstrating the occurrence of commercial quantities of coal.

PRODUCTIVE CAPACITY. The weight of forage that is produced within a designated period of time on a given area. In this document, productive capacity refers to pounds of air-dry forage produced on 1 acre in 1 year.

RAPTOR. A bird of prey, such as a hawk, eagle, or owl; a bird that feeds on meat taken by hunting.

RECHARGE (GROUNDWATER). The addition of water to an aquifer.

REDUCTION. The process by which a chemical is changed by combining it with hydrogen, or by decreasing the proportion of its electronegative parts.

RIPARIAN VEGETATION. Vegetation associated with or growing along a stream or river.

SCORIA. The local name for clinker or porcellanite; baked clay or shale with a dull, light-colored appearance, often found in the roof or floor of a burned-out coal seam.

SECONDARY AND TERTIARY OIL RECOVERY. Methods by which water is pumped into an oil-bearing formation to increase pressure in the formation and allow extraction of an oil-water mixture which can then be separated. These methods are used only after primary production (extraction by pressure in the oil pool alone) is no longer economical.

SEDIMENTATION. The process by which rock particles are eroded, transported and deposited, usually by flowing water.

SHEET EROSION. Erosion caused by sheets of flowing water, as distinct from erosion by streams flowing in channels.

STATIC HEAD. The height above a reference level of the surface of a column of water that can be supported by the static pressure at a given point.

STORAGE COEFFICIENT. The volume of water released from storage in a vertical column of 1.0 square feet when the water table or other potentiometric surface.

STRATIFIED SITE. A site at which more than one component or layer of cultural materials is present. Lower layers are older than upper ones.

STRUCTURAL DEPRESSION (BASIN). An area which is depressed and filled with sediment, bordered (in Wyoming) by faulted and uplifted rock.

STRUCTURAL RELIEF. The difference in elevation between the highest and lowest points of a formation or layer of rock in a given region.

STRUTTING GROUND. An area of open ground used year after year by sage grouse for courtship displays.

SURFACE-BASED INVERSION. A layer of air near the ground in which temperatures increases with altitude, the result being a zone in which pollutants become trapped rather than dispersing.

SYNCLINE. An elongated fold in rocks, the core of which is composed of stratigraphically younger rocks. A syncline is concave upward.

TEMPERATURE INVERSION LAYER. See surface-based inversion.

TOTAL SUSPENDED PARTICULATES. That portion of all particulate matter in the atmosphere consisting of particles too small to settle out.

TRANSMISSIVITY. In an aquifer, the rate at which water at the prevailing temperature is transmitted through a unit width under a unit hydraulic gradient.

UNDERSTORY. A layer of vegetation underlying a layer of taller plants.

WILDINGS. Seedlings or young plants naturally produced outside a nursery and dug for use as planting stock.

STORAGE COEFFICIENT. The volume of water released from storage in a vertical column of 1.0 square foot when the water table or other [illegible] surface declines [illegible].

STRATIFIED SITE. A site at which superimposed layers of cultural materials is present. [illegible] layers are under the [illegible] ones.

STRUCTURAL [illegible]. [illegible]

STRUCTURAL RELIEF. The difference in elevation between the highest and lowest points of a formation or horizon in a given region.

[illegible]. [illegible]

[illegible]. [illegible]

SYNCLINE. [illegible]

[illegible]. [illegible]

[illegible]. [illegible]

TRANSMISSIVITY. In an aquifer, the rate at which water of the prevailing temperature is transmitted through a unit width [illegible] under a unit hydraulic gradient.

[illegible]. [illegible]

[illegible]. [illegible]

APPENDIX D

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PROPOSED

BUCKSKIN

PROJECT

CHAPTER 1

DESCRIPTION OF THE PROPOSED ACTION

INTRODUCTION

The subject of this environmental statement is the proposed Buckskin surface mining project. The site-specific document contains a description of the proposed action, a description of the existing environment, an analysis of impacts associated with the proposed action, and an analysis of alternatives to that action.

HISTORY AND BACKGROUND

In May 1977, Shell Oil Company submitted a mining and reclamation plan for the Buckskin project to the office of the Area Mining Supervisor, U.S. Geological Survey, Billings, Montana, in accordance with 30 CFR 211 regulations promulgated in May 1976.

The Buckskin Mine would occupy federal coal lease, Wyoming 0325878. The lease was issued to Farmers Union Central Exchange on November 1, 1967, and was subsequently purchased by Shell Oil Company. Approval of the lease assignment was granted effective May 1, 1975. By approving these lease actions, the United States committed 84 million tons of coal reserves to mining. On May 4, 1977, Shell submitted an application to the Wyoming Department of Environmental Quality (DEQ) for a permit to mine. The application is pending at this time.

SURFACE MINING CONTROL AND RECLAMATION ACT

The mining and reclamation plan evaluated in this environmental statement (ES) was submitted for review prior to promulgation of the initial regulations (30 CFR 700) required under Sections 502 and 523 of the Surface Mining Control and Reclamation Act (SMCRA) of 1977 (PL 95-87), and has not been officially reviewed for compliance therewith. Therefore, the applicant's plan may not fully reflect the requirements of the initial regulations. However, it is believed that the plan presents sufficient data to allow analysis of the impacts associated with mining.

As required prior to approval by the Department of the Interior, the mining and reclamation plan has been returned to the operator for revision in accordance with the applicable initial regulations. Upon resubmission, the plan will be evaluated by the Office of Surface Mining (OSM) to insure compliance with the provisions of 30 CFR 700 and other federal regulations. The mining and reclamation plan cannot be approved until it conforms to all applicable federal requirements. After acceptance of the modified plan by OSM, any changes in environmental impacts caused by the modifications will be assessed.

In this ES, the initial regulations pertaining to SMCRA are considered as required federal mitigating measures, similar to other applicable regulations. The Regional Environmental Statement, Chapter 3, Planning and Environmental Controls, describes applicable provisions of SMCRA.

PROPOSED ACTION

Purpose and Objective

The federal authorization considered in this environmental statement (ES) is the approval of the mining and reclamation plan for Shell Oil Company's proposed Buckskin Mine. The purpose of the proposed action is to allow recovery of 80 million tons of low-sulfur, subbituminous coal over a 20-year period. Note that only 80 million tons of the 84 million tons of reserves would be extracted, because current mining technology does not permit the economic separation of the remainder from overburden and partings. The objective is to supply part of the national energy need, specifically an average of 4 million tons of coal per year. However, if demand increases, the mine could produce more than the 4 million tons per year average. The coal would be shipped to steam-generating plants in Oklahoma. Presently, 18 million tons of coal reserves are committed to Western Farmers, a Rural Electrification Administration cooperative, in Anadarko, Oklahoma. The remainder of the reserves is not committed to a particular consumer (personal communication, Larry Drew, Shell Oil Company 1978).

The description of the proposed action which follows is based on Shell's mining and reclamation plan, as well as personal communications from the company.

Location and Site Description

The 600-acre lease area is roughly 1 mile wide by 1 mile long and is located about 10 miles north of the town of Gillette, in Campbell County, Wyoming. The legal description of the lease area is as follows:

T. 52 N., R. 72 W., 6th P.M., Section 32, S½N½, S½
T. 51 N., R. 72 W., 6th P.M., Section 5, Lots 1, 3, 4

Shell Oil Company owns the surface of the land contained in the mineral lease.

Carter Oil Company, which owns the surface of the lands surrounding the lease, has granted the right of encroachment to Shell upon Lot 2, Section 5, T. 51 N., R. 72 W., 6th P.M., and upon a 1,000-foot corridor around the entire perimeter of the lease area for mine-related activities. This encroachment has been granted for reduction of the highwall and for construction of mine haul roads, ditches, and water diversions, and portions of the access road and railroad spur. The lease area and surrounding encroachment area constitute the permit area, which totals 1,760 acres.

Figure BU1-1 shows the proposed Buckskin Mine in relation to other coal mines in Campbell County, and Figure BU1-2 shows the Buckskin project location. Figure BU1-3 shows the coal ownership in the immediate area of the project, and Figure BU1-4 shows the surface ownership.

Mining Method

Shell proposes to use the open-pit, haulback method of surface mining, utilizing the truck and shovel technique (Figure BU1-5).

Employment

During the construction phase, Shell estimates employment at 25. When Buckskin Mine reaches full operation, employment would be approximately 125.

Surface Facilities

Construction of surface facilities would begin in 1979 and take 2 years. Offices, shops, parking areas, electrical substation, and water treatment plants would be located in the southeast corner of the lease area. Coal-handling equipment and the railroad loop would be located near the middle of the east edge of the lease. Coal-handling equipment would include a truck dump; a single-stage crushing unit; a belt conveyor to storage; a 50,000-ton-capacity, covered bunker storage facility; a load-out belt conveyor; a sampling tower; and load-out bins.

Surface facilities would occupy approximately 140 acres, beneath which no surface minable coal occurs.

Support Developments

Support developments consist of access and haul roads, railroad spur, power lines, and water supply and sewage treatment facilities.

Roads

Access to the mine site would be via a new road from U.S. Highway 14/16 to the southeast corner of the lease (Figure BU1-6). The road would be 2 miles long, and improved. Construction would begin in 1979. The road would require a right-of-way of 100 feet on each side of the centerline. Cuts, fills, and borrow areas would be needed, but the road would be completely reclaimed at the end of the mine life, unless the current surface owner requests otherwise. Natural drainage along the access road would be maintained by metal culverts and appropriate erosion control structures.

The roads built for the purpose of hauling coal and overburden would be 100 feet wide to allow two-way passage of haul trucks. Scoria (clinker) purchased locally may be used in the construction and surfacing of the haul roads. Haul roads would be traversed by water trucks as often as necessary (at least twice a day) to minimize fugitive dust. Roads would be maintained (graded) as required by weather conditions. All roads would have culverts where they cross major drainage channels; drainage ditches would be constructed along the sides of the roads. Haul roads would be removed and reclaimed as mining progresses. About 40 acres of roads would be off the areas to be disturbed by actual mining, and these would be reclaimed at the end of mine life. Roads would be designed in conformance with 30 CFR 715.17(l); these Office of Surface Mining (OSM) regulations require a road design which minimizes the impact of roads upon streamflow or runoff of the area.

Railroad Spur

As shown in Figure BU1-6, a 6-mile railroad spur and loop would be constructed for the Buckskin Mine. The spur would connect with the one serving Carter Oil's Rawhide Mine and thence to the existing Burlington Northern Railroad spur at a point east of Gillette. The Buckskin spur would require a 100-foot right-of-way. Construction would begin in 1979. If any part of the spur is required for other coal mines in the vicinity after Buckskin is mined out, that part would be left intact. Otherwise the railroad would be removed, and the right-of-way reclaimed. There is a very small quantity of minable coal under the railroad right-of-way, but the coal lessee (Carter Oil Company) does not anticipate mining any of it (personal communication, Larry Drew, Shell Oil Company 1978).

Power Lines

An existing 69-kv power line terminates near the load-out loop of the Carter Oil Company railroad spur. Shell proposes to extend the power line along the 100-foot railroad right-of-way, staying within its confines insofar as practical, to a new terminal point in the Buckskin Mine facilities area. The location of the substation is shown in Figure BU1-7. The overhead power line would be built to accepted engineering standards, including pro-

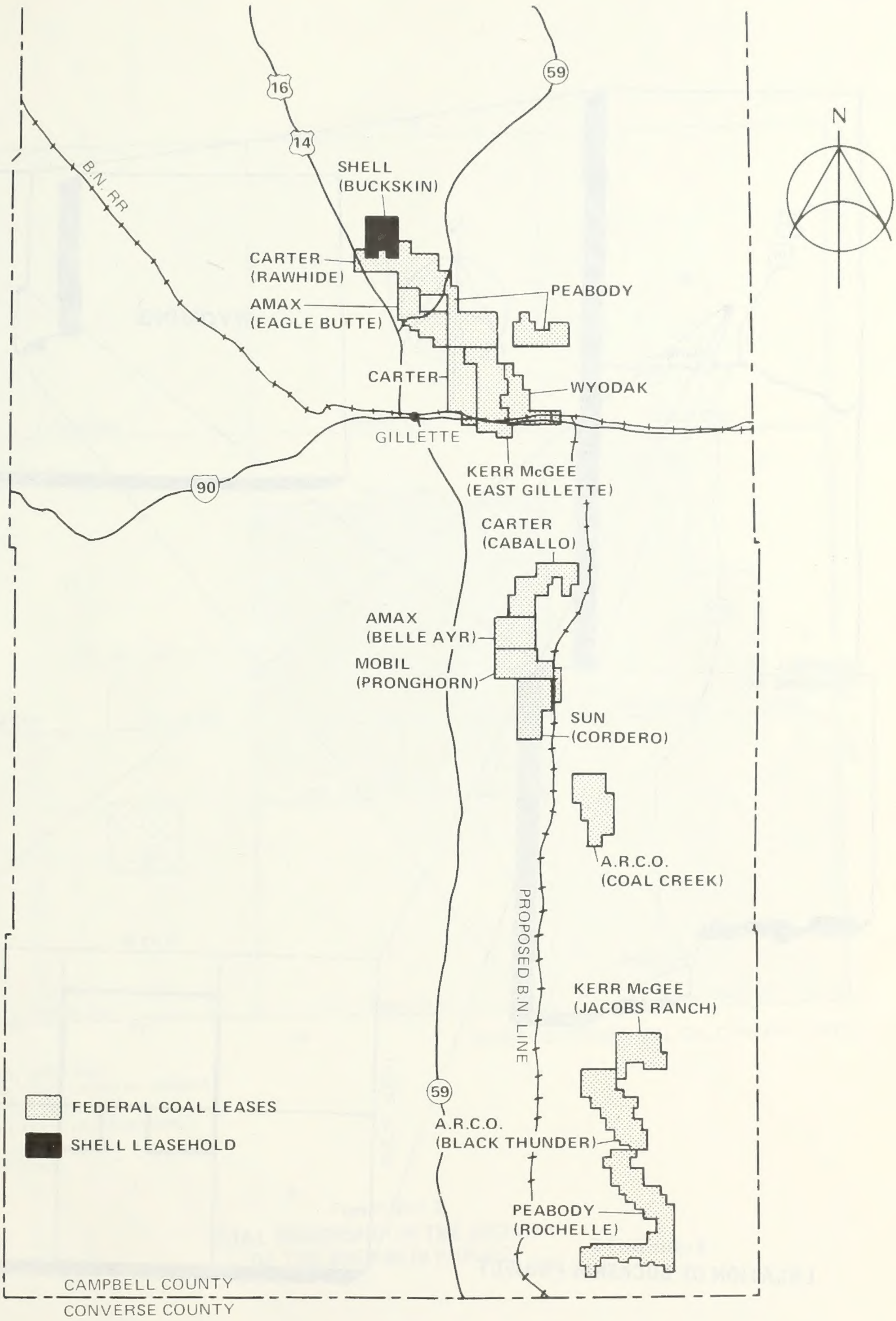

Figure BU1-1

LOCATIONS OF EXISTING MINES OR MINES PENDING APPROVAL ON FEDERAL COAL LEASES IN CAMPBELL COUNTY, WYOMING

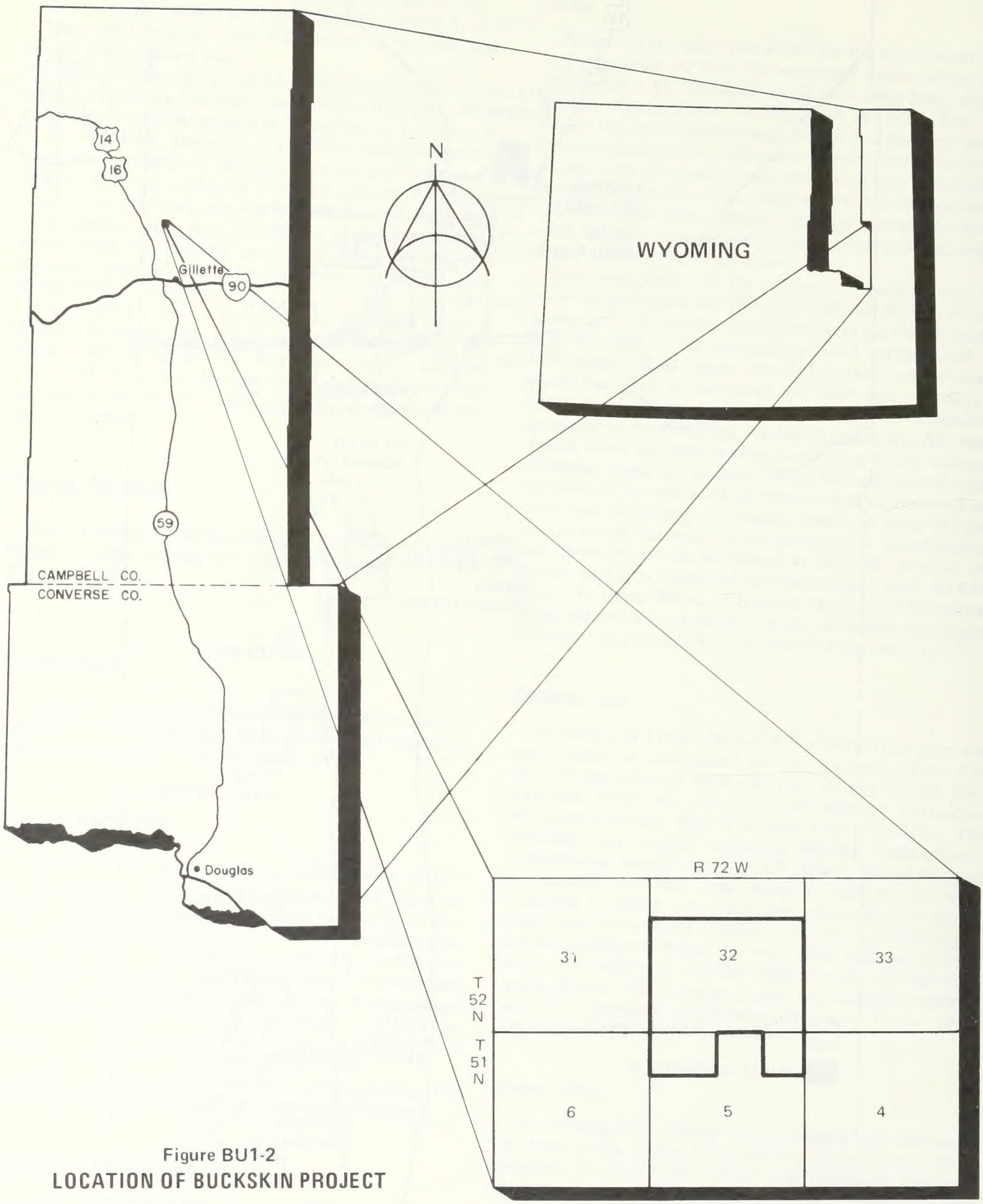

Figure BU1-2
LOCATION OF BUCKSKIN PROJECT

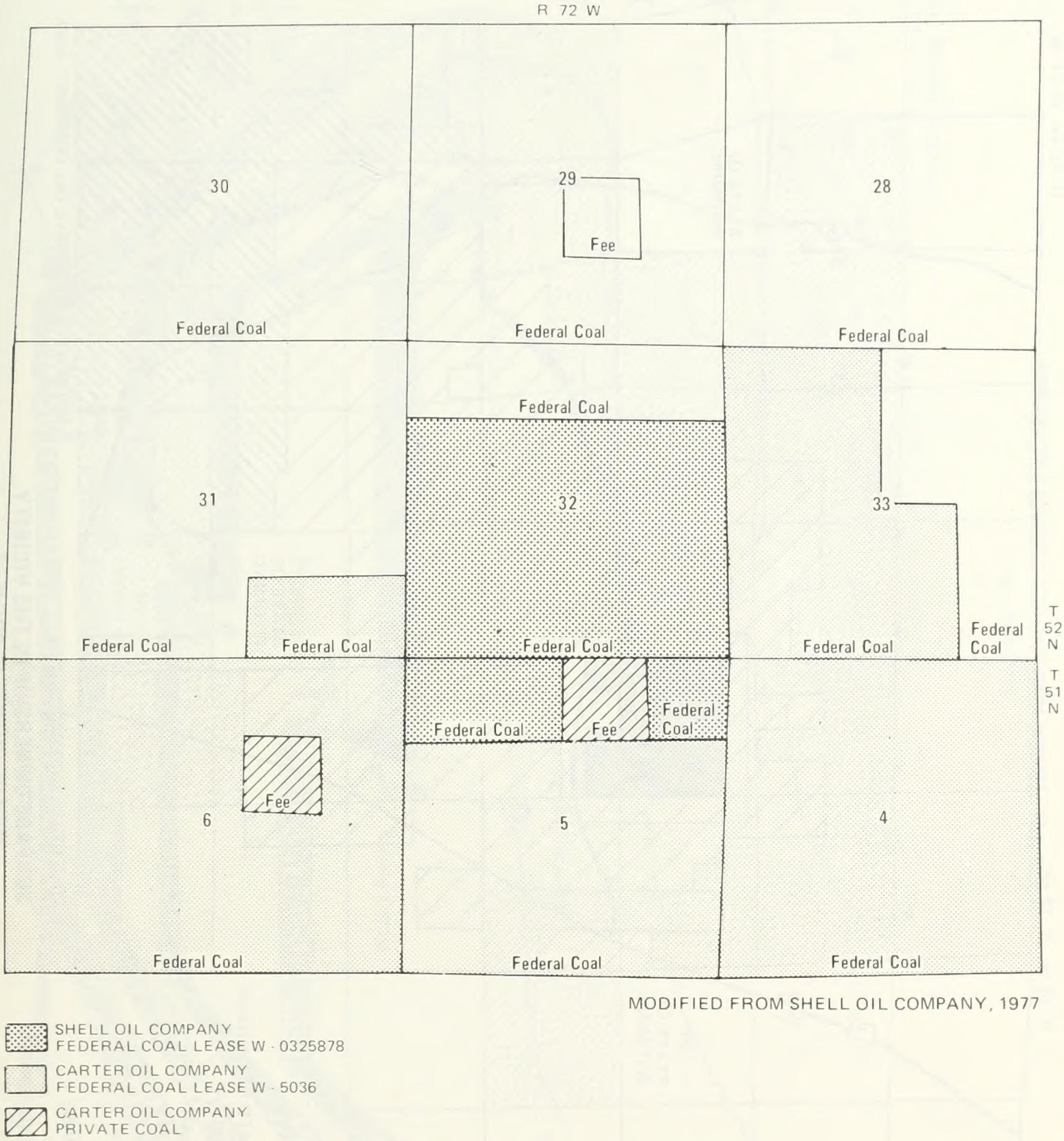

Figure BU1-3

COAL OWNERSHIP IN THE VICINITY OF THE BUCKSKIN PROJECT

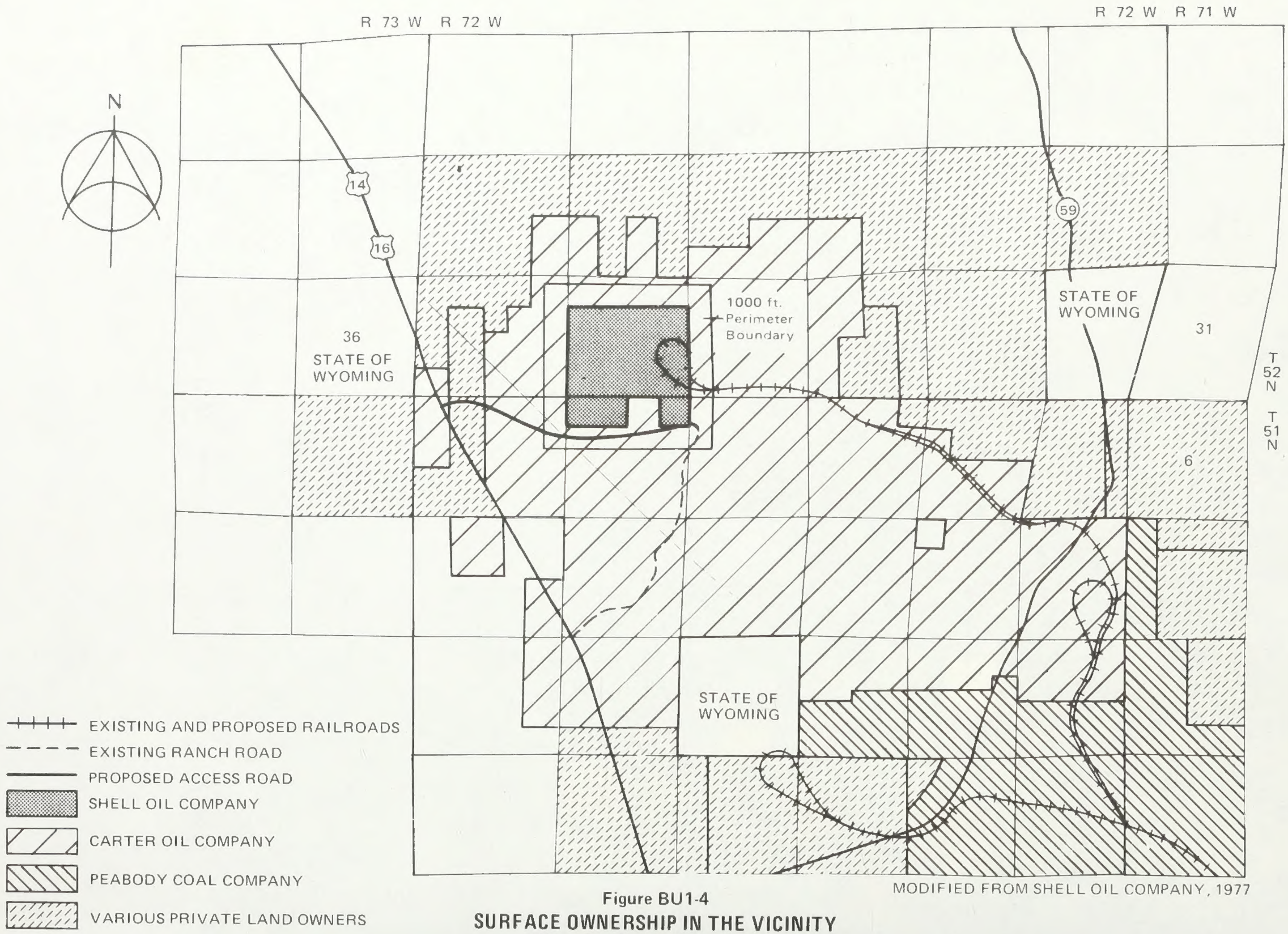

Figure BU1-4

SURFACE OWNERSHIP IN THE VICINITY OF THE BUCKSKIN PROJECT

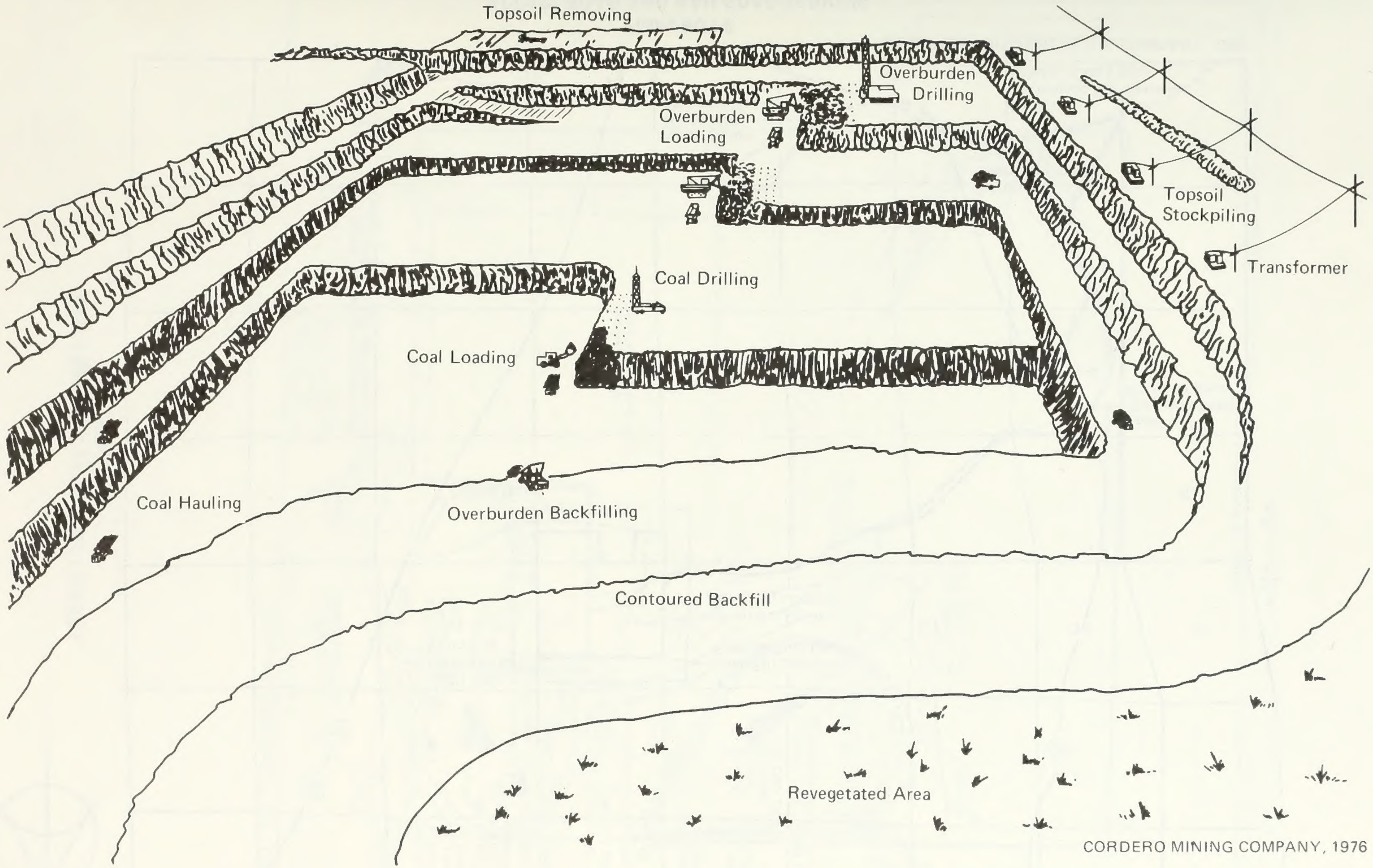

Figure BU1-5
OPEN–PIT, TRUCK AND SHOVEL MINING TECHNIQUE

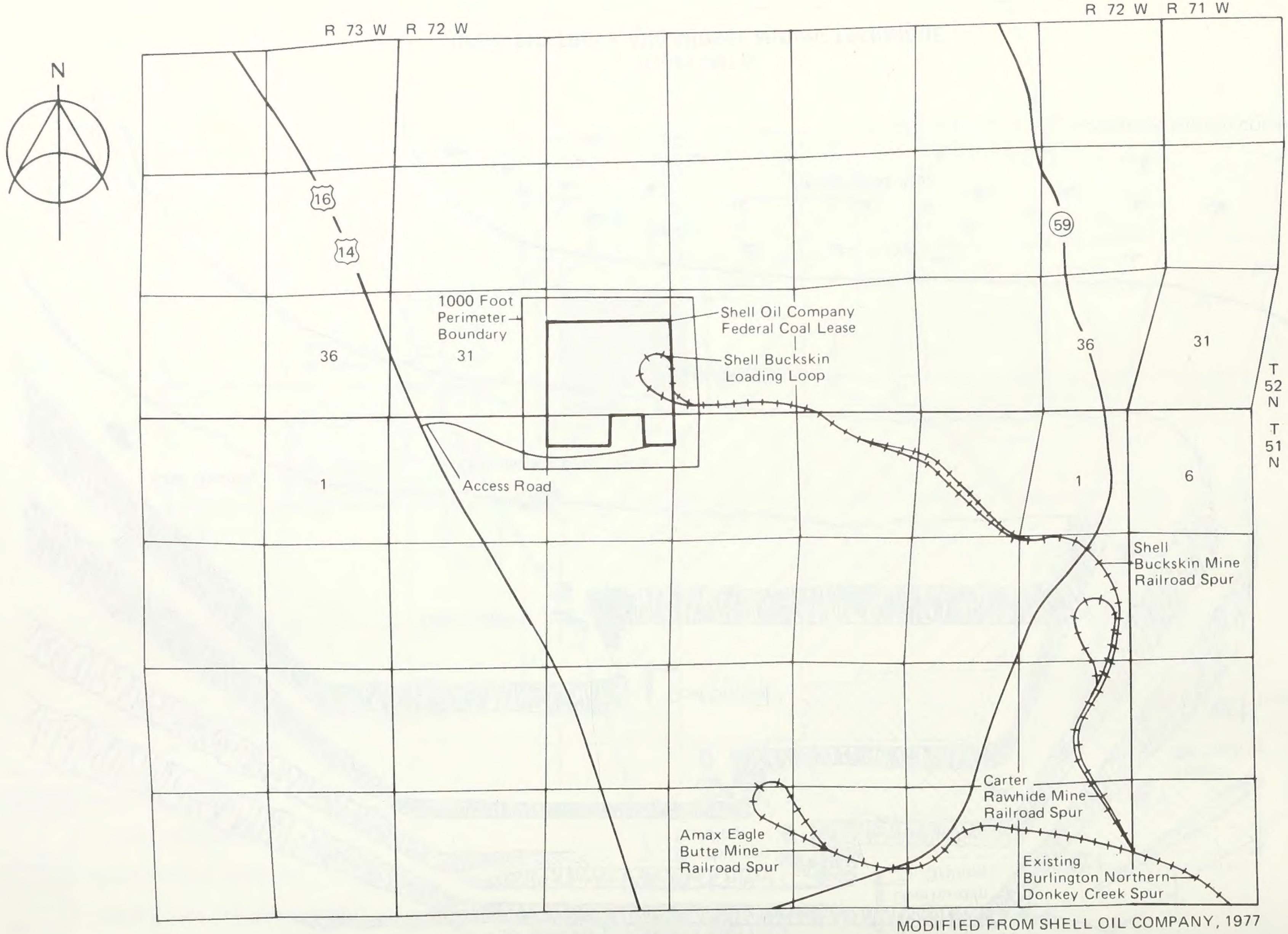

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Figure BU1-6
ACCESS ROAD AND RAILROAD SERVING BUCKSKIN PROJECT

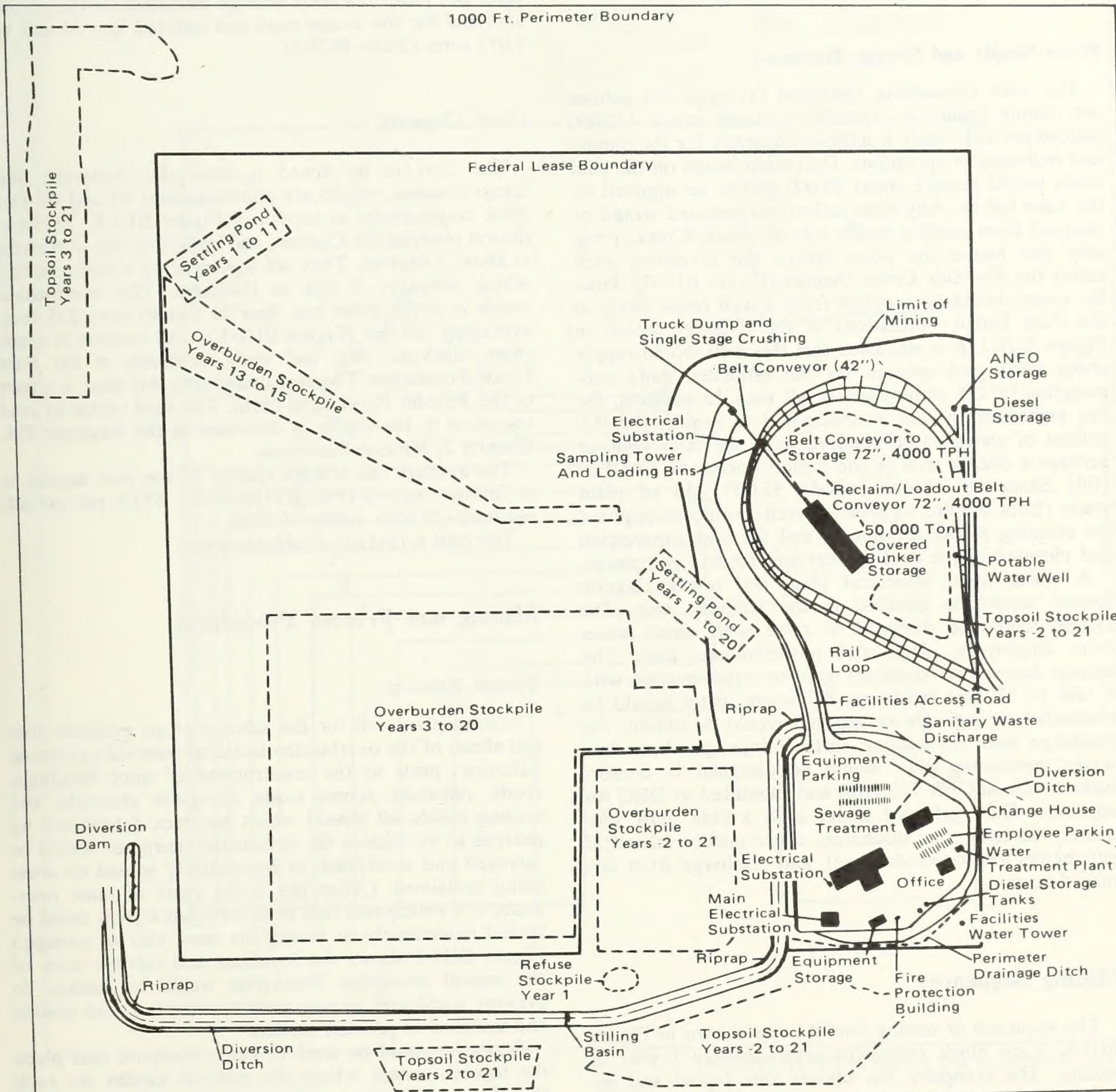

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Figure BU1-7

RAIL LOOP AND FACILITIES LAYOUT

visions for raptor protection. Power would probably be supplied by Tri-County Electric Association, Inc.

Water Supply and Sewage Treatment

The mine dewatering operation (average 300 gallons per minute (gpm)) is expected to supply about 432,000 gallons per day (gpd), a sufficient quantity for the mining and reclamation operations. Dust suppression on the haul roads would require about 40,000 gpd to be supplied by the mine inflow. Any mine inflow not required would be pumped from settling ponds into Rawhide Creek, probably just above the point where the diversion ditch enters the Rawhide Creek channel (Figure BU1-7). Potable water would be supplied from a well (most likely in the Fort Union Formation) at the location shown in Figure BU1-7. It is estimated that this well would supply about 4,655 gpd, enough for the estimated daily consumption of 125 employees for all uses. In addition, the fire protection system is anticipated to require 400,000 gallons of water, to be obtained from the same well, or perhaps a deeper well in the Lance Formation and Fox Hills Sandstone. Approximately 55,000 gpd of plant water (from the fire suppression well) would be required for cleaning mobile equipment and for dust suppression and cleaning of the coal crusher and loading equipment.

A waste water treatment plant and sewage lagoon system would be installed in the facilities area. The system would be designed to cope with waste water from employees, shop, and miscellaneous uses. The sewage lagoons are designed to store water to cope with a 120- to 150-day freeze-up. All waste water would be channeled through the system and would be suitable for discharge into the existing surface drainage. A surface water monitoring plan would be designed in conformance with 30 CFR 715.17(b) and submitted to DEQ for approval. Data gathered under such a plan must adequately describe total discharge, water quality (chemical parameters and concentrations), and discharge from disturbed areas.

Mining Sequence

The sequence of mining would be as shown in Figure BU1-8. Each block represents approximately 1 year of mining. The company has chosen this layout and sequence to provide for blending of areas of high-sulfur coal (located in a pocket close to the facilities area) with areas of low-sulfur coal, in order to meet Environmental Protection Agency standards.

Due to varying coal quality, it would be necessary to keep at least a 2-month (0.7 million-ton) supply of coal completely exposed by removing overburden ahead of the active mining operations. This pit inventory would serve a twofold purpose: it would allow blending of the coal and would provide a safety margin against inclement weather.

The acreage disturbed each year would vary, but after the first 3 years when 500 acres would be disturbed (including facilities construction), mining would average 30 acres per year. The total acreage disturbed on the permit area and for the access road and railroad spur would be 1,071 acres (Table BU1-1).

Coal Deposit

The coal to be mined is from the Anderson and Canyon seams, which are approximately 40 and 64 feet thick respectively, as shown in Figure BU1-9. The Anderson overlies the Canyon, and both beds dip northwest at about 3 degrees. They are separated by a shale parting which averages 3 feet in thickness. The overburden varies in depth from less than 20 feet to over 215 feet, averaging 101 feet (Figure BU1-10), and consists of sandstone, siltstone, clay, and shale sediments of the Fort Union Formation. The coal underlying this lease is a part of the Powder River Coal Field. The total extent of coal resources in the region is discussed in the Regional ES, Chapter 2, Mineral Resources.

The average run-of-mine quality of the coal deposit is as follows: ash—6.11%, BTUs—8,183 BTUs per pound, moisture--29.80%, sulfur—0.51%.

The coal is ranked as subbituminous.

Mining and Process Procedures

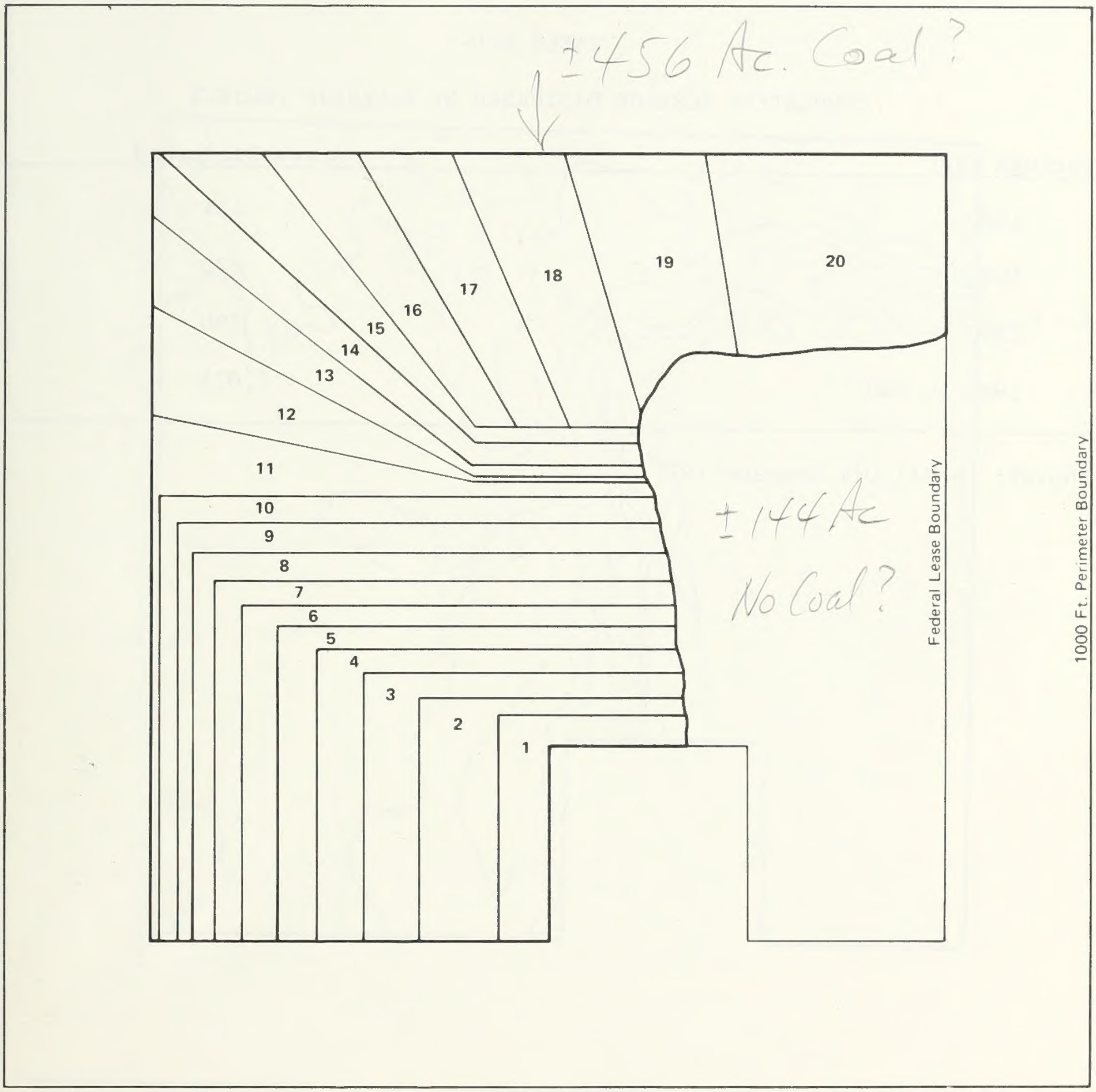
Topsoil Removal

Mining plans call for the salvage of all available topsoil ahead of the overburden and coal removal processes. Likewise, prior to the construction of mine buildings, roads, railroads, access roads, diversion channels, and settling ponds, all topsoil which has been determined by analysis to be suitable for reclamation purposes would be salvaged and stockpiled, or immediately spread on areas being reclaimed. (After the initial years of mine operation, it is anticipated that most salvaged topsoil could be spread immediately or during the same year as salvage.) Figure BU1-7 shows the locations and relative sizes of the topsoil stockpiles. Stockpiles would be marked to prevent accidental mixing with overburden, and seeded and mulched to prevent erosion.

Scrapers would be used to load, transport, and place the topsoil, except where the removal depths are such that front-end loaders might be used advantageously to load haul trucks for this operation. It is anticipated that approximately 500 tons of topsoil could be moved per day by one 30-yard-capacity scraper. Topsoil handling would be done in conformance with 30 CFR 715.16, which delineates methods to remove, segregate, analyze, store, and replace topsoil.

Overburden Removal

The overburden would be removed with a large mining shovel after blasting where necessary. The overburden would be removed in benches with heights rang-



MODIFIED FROM SHELL OIL COMPANY, 1977

NOTE: Numbers represent years of mine operation

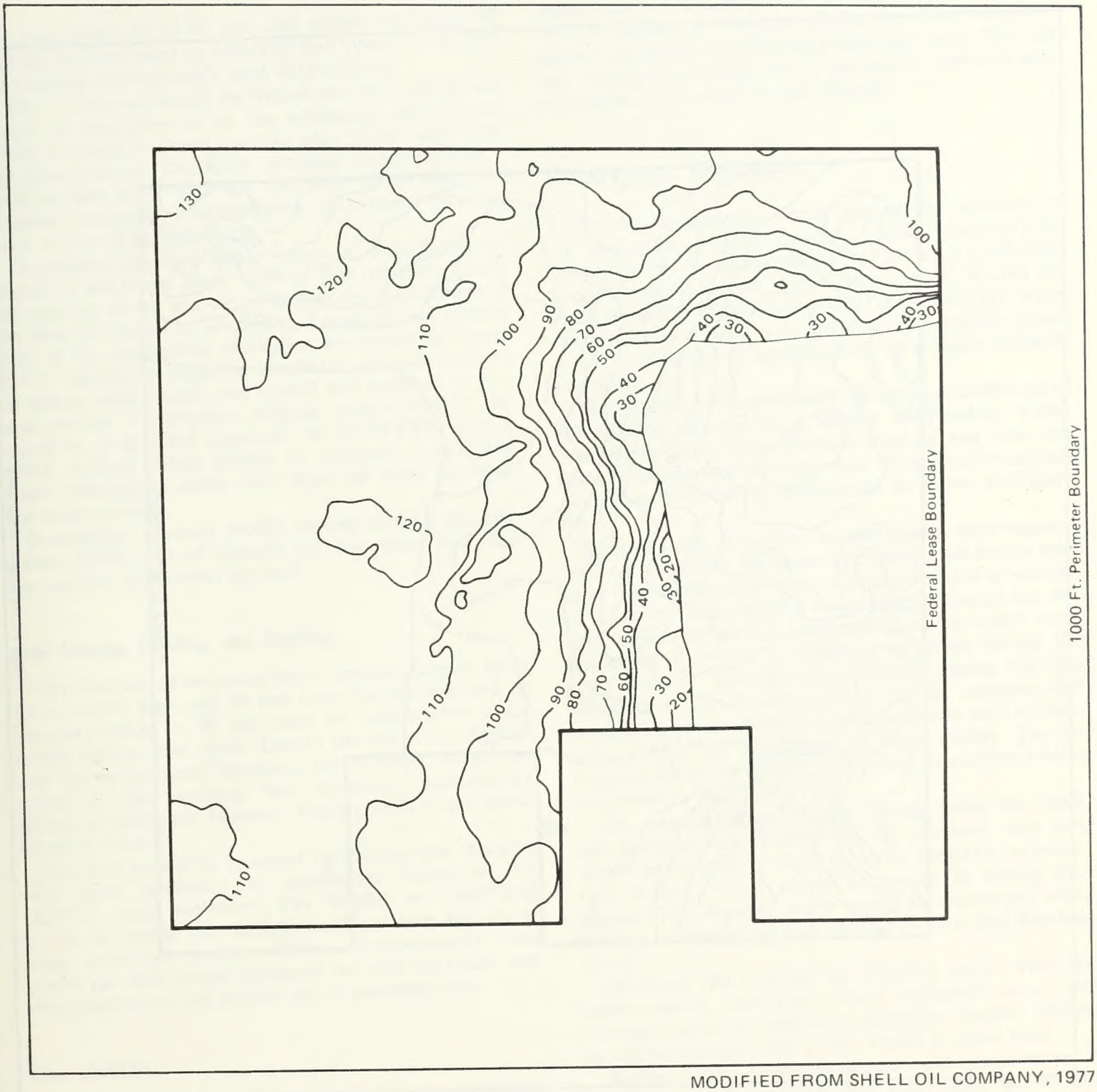
Figure BU1-8
MINING SEQUENCE

TABLE BU1-1

CUMULATIVE ACREAGE DISTURBED BY BUCKSKIN PROJECT

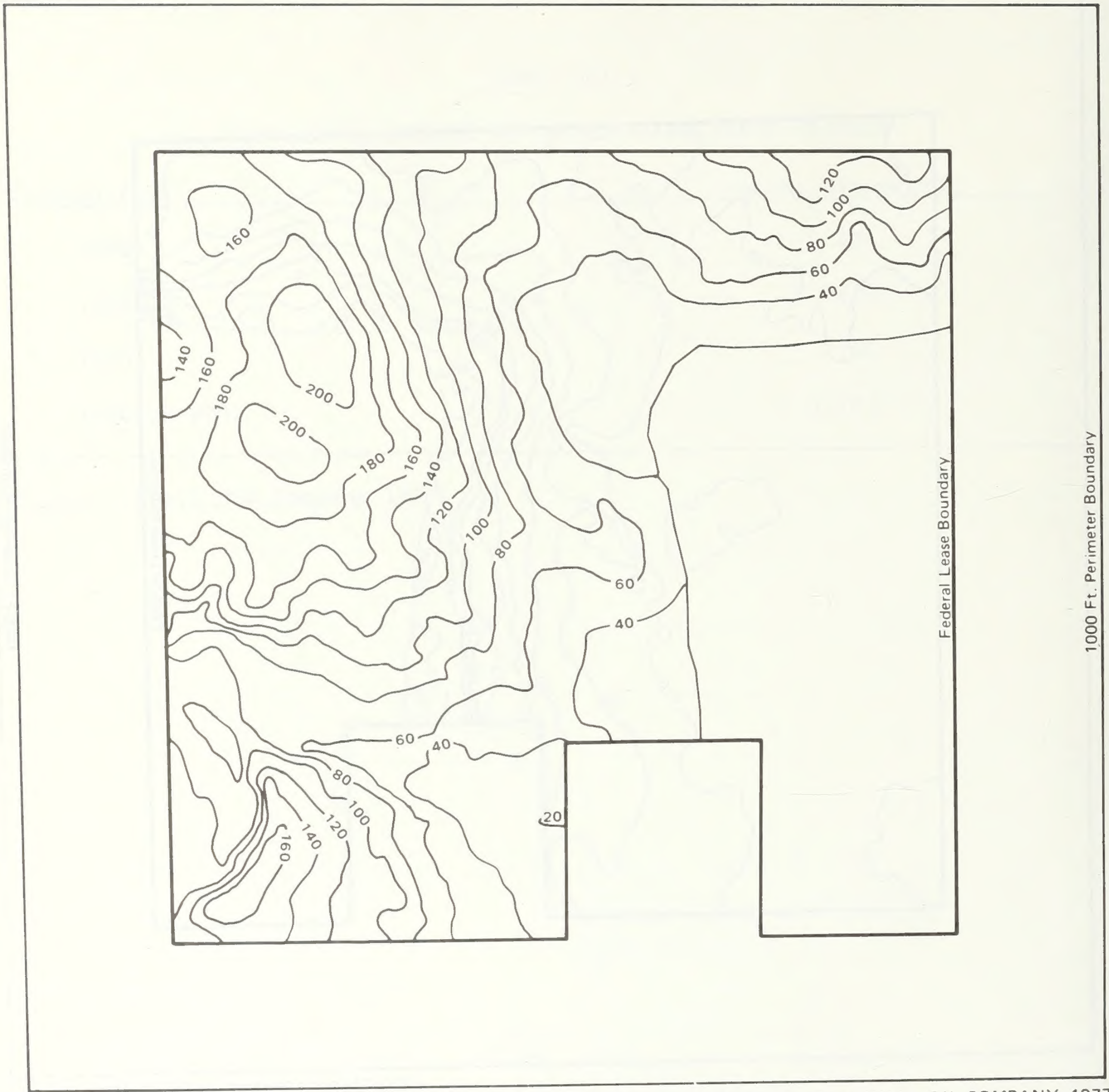
Through Year	Acres Disturbed
1980	434
1985	670
1990	790
1990 to 2001	1,071

Source: Shell Oil Company 1977



NOTE: Thickness Measured In Feet

Figure BU1-9
COAL THICKNESS MAP



MODIFIED FROM SHELL OIL COMPANY, 1977

NOTE: Thickness Measured In Feet

Figure BU1-10
OVERBURDEN THICKNESS MAP

ing from about 40 to 60 feet, and widths averaging 90 feet for benches used as two-way haul roads, or 50 feet for benches not commonly used as haul roads.

The overburden would be loaded into haul trucks and placed in stockpiles or on the advancing spoil bench, where it would be dozed over the edge of the bench into the mined-out pit. This latter operation would provide a spoil surface at or near the elevation of the final reclaimed topography, necessitating only minor grading prior to topsoil replacement.

Overburden material which cannot be immediately replaced in mined-out areas, such as that removed during the opening of the box cut or needed for replacement in the final pit, would be stockpiled. Locations and relative sizes of the overburden stockpiles are shown in Figure BU1-7. Stockpiles would be marked to prevent accidental mixing with topsoil, and seeded and mulched to prevent erosion. Overburden disposal sites would be designed to meet OSM standards set in 30 CFR 715.15, which outlines design criteria for disposal of spoil and waste materials in areas other than the mine workings and excavations.

Overburden removal would require shifting approximately 10,000 tons of material per day, using four 120-ton-capacity haul trucks per shift.

Coal Mining, Loading, and Hauling

The coal would be mined from benches ranging from 30 to 60 feet high, and 90 feet wide for benches used as two-way roads, or 50 feet wide for benches not commonly used as haul roads. Due to the dip of the deposit and the varying coal thickness, bench height would increase as the working face advances, necessitating mining in additional benches. The highwall slope would be about 1:0.6.

The coal would be loosened by drilling and shooting with (most probably) an ammonium nitrate-fuel oil (ANFO) type explosive. The blasted or "shot"coal would be loaded into haul trucks by mining shovels or large front-end loaders. Three 85-ton-capacity haul trucks per shift would transport the coal up ramps and along benches to the crusher site or stockpile area.

Coal Handling

Coal would be dumped from the trucks into the single-stage crushing unit and crushed to 2-inch size. From here it would be transported by a 72-inch belt conveyor to a 50,000-ton-capacity, covered bunker storage facility. To maintain production in case of equipment breakdown and to assist in blending coals, either crushed or mine-run coal may be stored in an active surge stockpile in the area of the coal-handling facilities. The surge pile would seldom exceed 6,000 tons at any one time.

From the bunker, the coal would be conveyed to the sampling tower and load-out bins and loaded into rail cars. The coal would be transported by unit train to markets in Oklahoma. The unit trains would consist of 100 to 120 cars of 100-ton capacity each. The number of unit trains required would depend on coal production rates. With production at 4 million tons per year, unit train frequency would be approximately eight per week. The rail cars would be weighed before leaving the facilities area to measure the amount of coal shipped.

Watercourse Diversions

The mining sequence would require the diversion of the intermittent stream, Rawhide Creek. Temporary diversion would be accomplished by use of a 7,500-foot-long, 65-foot-wide, and 12-foot-deep channel around the south boundary of the lease area (Figure BU1-11). After completion of mining and reclamation, Rawhide Creek would be returned to approximately its original (present) location.

The location of the proposed rail loop precludes use of the existing channel in a section of Rawhide Creek downstream from the diversion channel and near the eastern boundary of the lease area. Therefore, an earthen ditch bypass would be constructed as shown in Figure BU1-7.

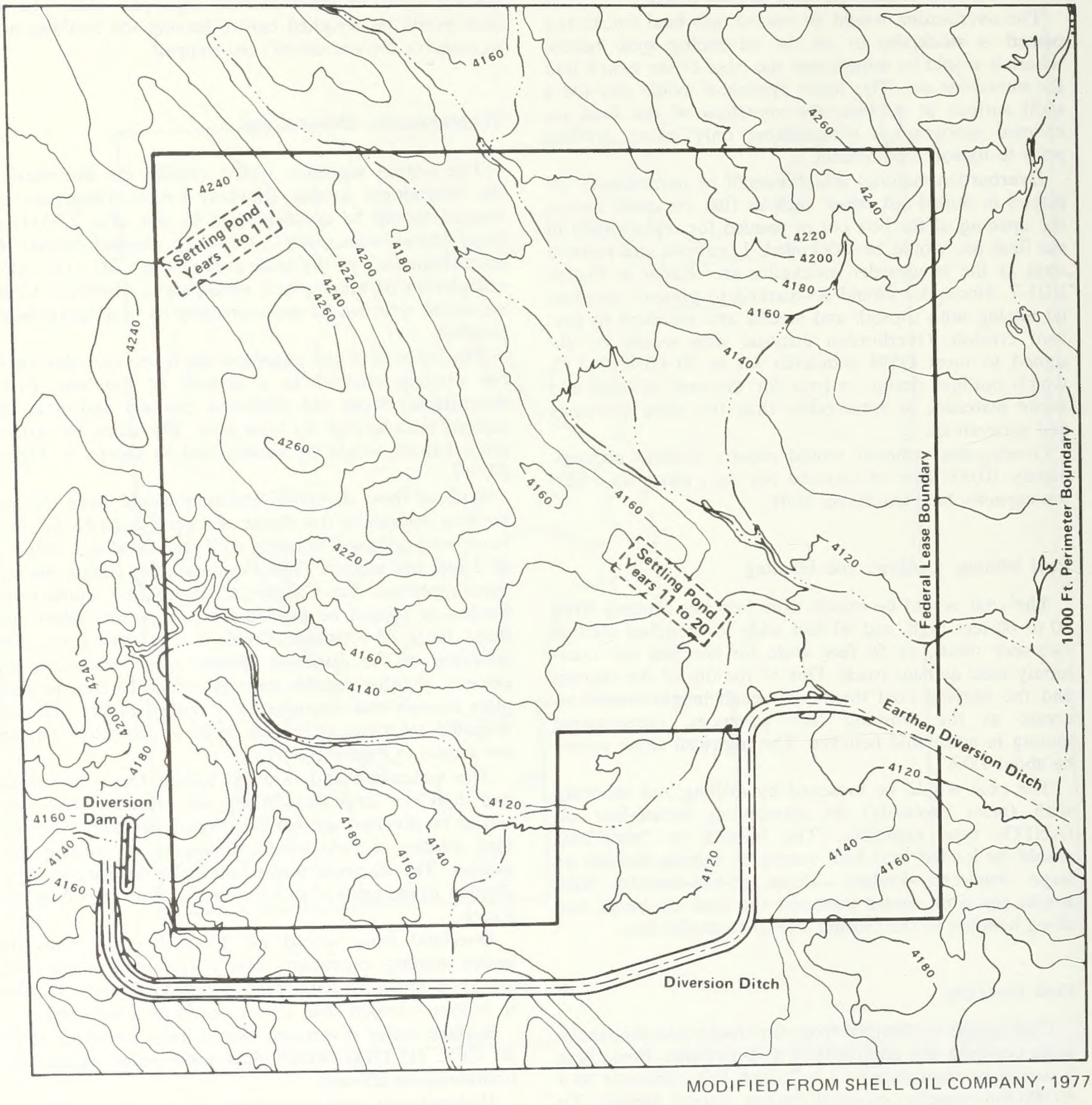
Both of these diversion channels would have channel beds on essentially flat slopes and grass-lined banks; they have been designed to carry a 20-year flood at a velocity of 2 feet per second. (The flood-capacity design has not been approved. See Chapter 4.) In no case would overburden or topsoil be pushed into, or placed below, the flood level of Rawhide Creek except during the construction of the diversion. Rock riprap, concrete, soil cement, or other suitable material would be used to minimize erosion and degradation of water quality. The anticipated locations of several of these protective devices are shown in Figure BU1-7.

The watershed and flow of Spring Draw are small, and therefore large runoffs are not expected. Any flow would be diverted around the active operation in temporary ditches, which would be moved as mining progresses. The diverted water would be discharged along existing drainageways and allowed to flow into Rawhide Creek.

Overland flow would be diverted away from the active mining operation, newly reclaimed areas, and stockpile areas by temporary diversion ditches. Ditches in existence longer than 1 year would be grass lined.

Surface water diversions would meet standards set in 30 CFR 715.17(a), which deal with water quality and limitations on effluent.

Underground water resources are present in the area, as they are throughout most of the region. Mining would disrupt the existing shallow aquifer, which is the overlying sandstone and the coal itself. Mine inflow during the operation would average 300 gpm. Groundwater would be protected by pumping mine inflow from the pit and discharging the water (after treatment, if necessary) into the surface water system; this would prevent the addition of dissolved and suspended solids into the groundwater, which might occur if the mine inflow were pumped directly back into the groundwater system.



NOTE: Contour interval 20 feet
Elevation in feet above sea level

Figure BU1-11
SETTLING PONDS AND DIVERSION DITCHES

Settling ponds would be utilized for removal of particulates in the water, as well as for sewage treatment. The ponds would be removed during the course of mining or at the completion of mining activities. The locations of these settling ponds are shown in Figure BU1-11.

Groundwater monitoring in wells is currently being done and would continue throughout the mine life to assess any changes resulting from the mining operation. Figure BU2-8 shows the location of monitor wells on the lease. Undesirable changes are not expected, but if they occur, the appropriate authorities would be notified as required by law, and corrective measures would be taken.

Reclamation Activity

The annual reclamation diagram (Figure BU1-12) and Table BU1-2 show the reclamation sequence and schedule.

All reclamation activity at the proposed Buckskin Mine must conform to the stipulations and requirements of the federal coal lease involved, the requirements of the Wyoming State Environmental Quality Act of 1973, and other applicable federal, state, and local regulations and laws. Compliance with these laws would be enforced through regular inspections by federal and state officials.

Present and Future Land Use

Grazing by livestock and wildlife is the major current land use of the proposed mine area. Some small areas along Rawhide Creek are used for hay production. A cultivated field (wheat and barley) at the southern edge of the permit area would be disturbed during construction of the water diversion structures. (This has been determined to be not prime farmland.) There are no active oil or gas wells on the permit area or adjacent lands.

Shell proposes to reclaim the disturbed land primarily for grazing use, although the change in use of the cultivated fields has not been approved. Due to the relatively gentle slopes in the area following mining, portions of the land could be used for hay production. Some areas of the lease would also be planted with shrubs and/or trees for wildlife use. This proposal conforms with the State of Wyoming's regulations.

Shaping of Overburden (Backfilling)

The faces of the overburden and coal bed in the highwall of the final pit would be reduced by blasting. The overburden and coal would be drilled and blasted in accordance with 30 CFR 715.19 regulations concerning use of explosives. The final pit area would be backfilled, graded, and contoured to blend with the surrounding topography and to provide drainage. The postmining topography would have slopes ranging from .5% to 31%, with an average slope of 4.7%; a maximum slope of 31% (17 degrees) would occur at the mineral lease boundaries where the highwalls are blended with the existing topography. (The premining slopes range from 1% to 31%, with an average slope of 7.5%.) Reclaimed highwall slopes greater than the average natural slope (31% vs. 7.5%) might be necessary in order to minimize the amount of affected lands; the use of reclaimed highwall slopes of 7.5% maximum could result in as much as a 125% increase in the amount of the disturbed lands in the area of highwall reduction.

Final shaping of the overburden would be done prior to the placement of topsoil, and would normally occur during the period when seeding of the permanent cover is impractical (usually May 1 through October 15). Backfilling and grading would be done in conformance with 30 CFR 715.14 regulations. These regulations set forth criteria for all backfilling and grading necessary, including slopes, depressions, gullies, overburden conditions, and stabilization.

Placement of Topsoil

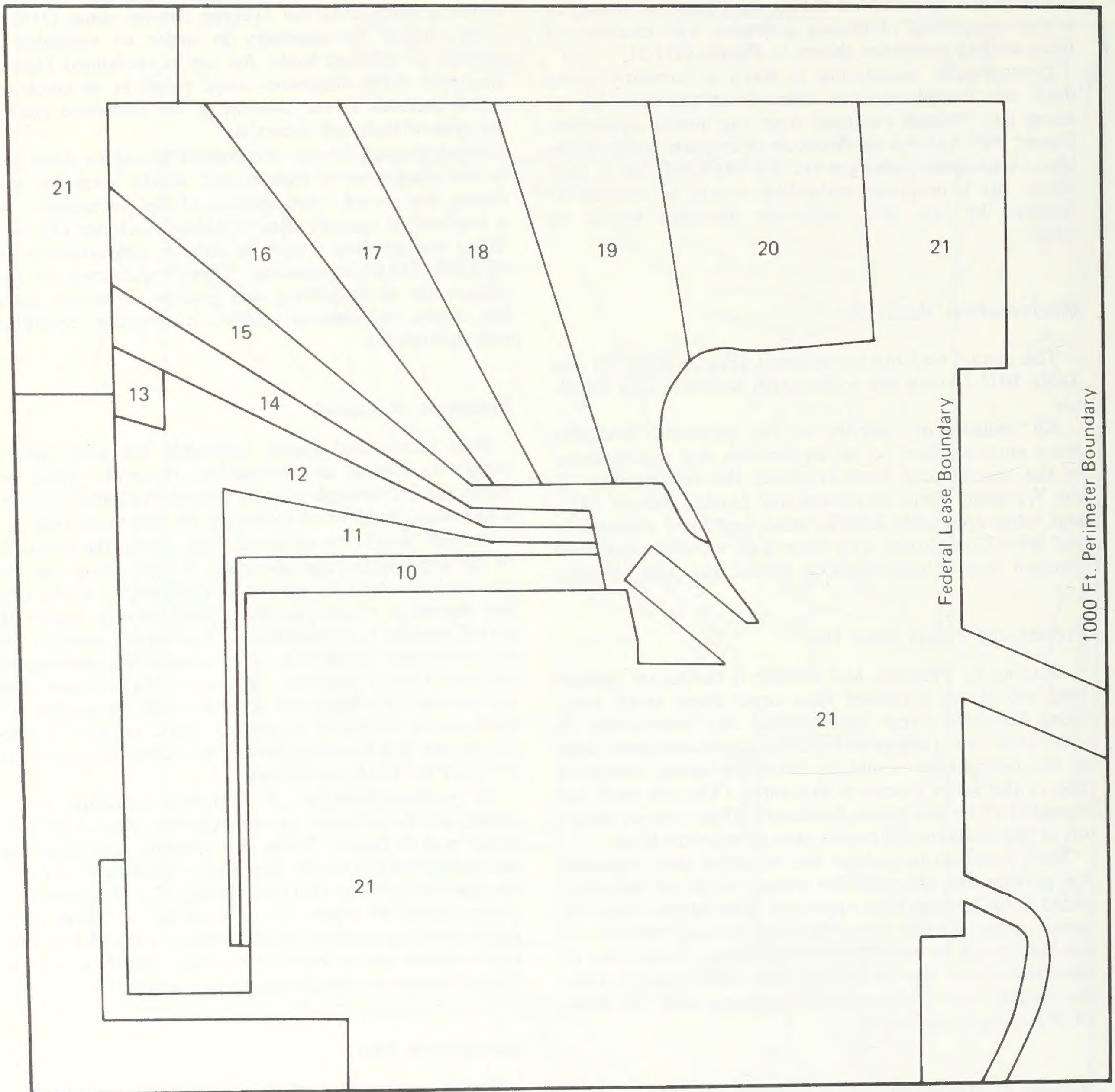
Soils tested and found unsuitable for plant growth would be treated as overburden. However, Shell estimates there is enough suitable topsoil available to replace a minimum depth of 18 inches on all disturbed areas.

Topsoil would be obtained from either the stockpiles or the ongoing salvage operation. To the extent practicable, topsoil would be applied at right angles to the slope and left in a rough condition until shortly before the actual seeding is accomplished. This would provide protection against wind and water erosion and increase the accumulation of moisture. Where the shaped spoil material is relatively level, the topsoil would be applied in a north-south direction to control wind erosion. Topsoil placement and handling would be conducted according to 30 CFR 715.16 regulations.

To prevent creation of a cloddy structure, topsoil would not be salvaged or redistributed when it is excessively wet or frozen. When it is possible, topsoil salvage and redistribution would take place immediately prior to the planting seasons (fall and spring). If it is necessary to place topsoil at other times, it would be seeded with quick-growing annuals (such as oats or barley) to minimize erosion and to contribute a dead mulch into which the permanent species would be seeded later.

Revegetation Plan

Shell's revegetation plan was developed primarily to support domestic livestock grazing; this complies with 30 CFR 715.13 regulations, which require the restoration of lands affected to a condition capable of supporting the uses which existed prior to mining, or higher or better uses of which there is reasonable likelihood. Note that the impact analysis in Chapter 3, Soils, disputes Shell's statement that 100% of premining productivity can be restored. A permanent vegetative cover of predominantly native grass species, which are perennial, self-renewing, and adapted to the climate of the region, would be reestablished on all lands disturbed by mining or for surface or support facilities. Although the seed mixture and



MODIFIED FROM SHELL OIL COMPANY, 1977

NOTE: Numbers represent years of mine operation

Figure BU1-12
RECLAMATION SEQUENCE

TABLE BU1-2

RECLAMATION SCHEDULE

Year	Acres Disturbed	Cumulative Acres Disturbed	Acres Reclaimed	Cumulative Acres Reclaimed	Acres Undisturbed	Disturbed Acres Unreclaimed
- 2	362	362	-	-	709	362
- 1	72	434	-	-	637	434
1	23	457	-	-	614	457
2	78	535	-	-	536	535
3	76	611	-	-	460	611
4	44	655	-	-	416	655
5	15	670	-	-	401	670
6	28	698	-	-	373	698
7	34	732	-	-	339	732
8	25	757	-	-	314	757
9	17	774	-	-	297	774
10	16	790	14	14	281	776
11	24	814	23	37	257	777
12	39	853	65	102	218	751
13	21	874	7	109	197	765
14	13	887	32	141	184	746
15	22	909	40	181	162	728
16	15	924	31	212	147	712
17	18	942	31	243	129	699
18	25	967	37	280	104	687
19	51	1,018	70	350	53	668
20	40	1,058	55	405	13	653
21	13	1,071	666	1,071	-	-
TOTAL	1,071		1,071			

Source: Shell Oil Company 1977

seeding techniques may be adapted to meet the requirements of the Wyoming Department of Environmental Quality (DEQ), Land Quality Division, Shell proposes to use the mixtures and rates shown in Table BU1-3. DEQ has recommended against the use *of Caragana,* but the final seed mixture has not been determined. In areas where wildlife habitat is to be provided, native trees and shrubs would be hand planted from nursery stock or transplanted from areas being stripped.

Prior to seeding, the topsoil would be ripped to a depth of at least 18 inches to allow root penetration and water retention. Additional shallow ripping may be required to assure a loose, friable soil surface. Seed would be drilled on the contour to a depth of 1 inch in sandy soils and ½ inch in clayey soils. If seed must be broadcast in areas too steep or rocky for drill-seeding equipment, soil material would be hand raked or harrowed over the seed. Topsoil handling and seedbed preparation would be done in conformance with 30 CFR 715.16 and 715.20; the former regulations define topsoil handling procedures so as to minimize degradation and loss, and the latter regulations establish revegetation procedures, timing, methods, and success standards.

Needed fertilizer, as determined by testing of the topsoil, would be applied prior to seeding or after seedling emergence. Annual applications of fertilizer are not planned. Except in abnormally dry years, irrigation of newly planted areas would not be considered (except for the trees and shrubs); Shell would time seeding to take full advantage of natural available moisture (between mid-October and late April). To prevent wind or water erosion and loss of moisture, mulches will be applied to the seeded areas. To accumulate moisture on exposed slopes or for trees and shrubs, snow fences may be constructed. Herbicides would be used according to state and federal regulations to control noxious weeds in newly planted areas. Livestock grazing would be excluded from reclaimed areas for at least 2 years.

Decommissioning and Abandonment

At the end of mine life, all surface facilities would be removed. The land surface involved would be ripped to loosen compaction, spread with a minimum of 24 inches of topsoil, and revegetated.

The railroad spur and access road could be retained, as might some buildings, if requested by the surface owner at the time.

Pollution Control Methods

Methods proposed by Shell to control air pollution from coal dust and blowing soil are as follows:

1. All unsurfaced roads would be watered a minimum of twice a day, and more if necessary.
2. Topsoil and overburden storage piles would be seeded with fast-growing annual and/or perennial species.
3. Coal would be stored in a covered bunker.

Methods proposed by Shell to prevent water pollution from sediment or toxic material are as follows:

1. The bottoms and sides of temporary water diversion structures would be grass lined.
2. Culverts or bridges would be installed to prevent traffic through drainages.
3. Diversion ditches would be designed to discharge away from topsoil and overburden storage areas, and newly reclaimed areas.
4. Riprap or concrete would be used at curves in diversion ditches.
5. Overburden material determined to be toxic or a health hazard would be buried at the bottom of the mine pit, or well below the root zone, and kept away from stream channels or drainages. Such material is identified from analyses of materials obtained during a coring program. At present, no data is available as to the presence or absence of toxic materials at the Buckskin lease, but general data from the Powder River Basin indicate that toxic materials present only a slight problem. It is expected that Shell would be monitoring the overburden characteristics during the mining operation, and would take any necessary steps to deal with any toxic materials discovered.
6. If runoff leaches toxic material from overburden or coal stockpiles, the contaminated water would be impounded and treated prior to release into surface drainage.

Methods proposed by Shell to prevent or control fires are as follows:

1. Coal storage areas would be designed to eliminate fire hazards from spontaneous combustion.
2. A fire protection system is planned for the surface facilities area.
3. Combustible material uncovered during mining would be buried or stored in waste piles stabilized with layers of incombustible and impervious material.

AUTHORIZING ACTIONS

This section identifies governmental authorizations which would be required to implement the proposed action.

Assistant Secretary of Energy and Minerals

The Assistant Secretary shall approve the mining permit application (including the mining and reclamation plan) and significant modifications or amendments thereto prior to commencement of mining operations by the company.

Office of Surface Mining (OSM)

OSM, with the concurrence of the surface-management agency (Bureau of Land Management) and USGS, recommends approval or disapproval of the mining and reclamation plan to the Assistant Secretary of Energy

TABLE BU1-3

PROPOSED SEEDING RATES (POUNDS OF PURE LIVE SEED PER ACRE)

Species	Basic Mixture	Heavy Soil Uplands	Heavy Soil Depressions	Sandy Soil	Wildlife Areas	Wet Areas
Agropyron smithii western wheatgrass (Rosana)	3	4	4		2	4
Agropyron dasystachyum thickspike wheatgrass (Critana)	3	3	2	3	2	
Agropyron riparium streambank wheatgrass (Sodar)	3	3	2	3	2	
Onobrychis viciaefolia sainfoin (a legume)			3			
Oryzopsis hymenoides Indian ricegrass				2	1	
Stipa viridula green needlegrass	1	1			1	
Phalaris arundinacea reed canary grass						3
Agropyron elongatum tall wheatgrass (Orbit)						4

TABLE BU1-3
(cont'd)

PROPOSED SEEDING RATES (POUNDS OF PURE LIVE SEED PER ACRE)

Species	Basic Mixture	Heavy Soil Uplands	Heavy Soil Depressions	Sandy Soil	Wildlife Areas	Wet Areas
Astragalus cicer Cicer milkvetch (a legume)						1
Atriplex canescens fourwing saltbush				2	2	
Rosa spp. rose					*	
Caragana pymaea pygmy caragana					*	

Source: Shell Oil Company 1977

Note: Rates of seeding are for drilled stands. If broadcast seeding is necessary, the rate of seeding should be doubled.

* Amount used per acre would depend upon the size and frequency of the spot seeding areas selected.

and Minerals. Whenever a state has entered into a state-federal cooperative agreement with the Secretary of the Interior, pursuant to Section 523(c) of the Surface Mining Control and Reclamation Act (SMCRA), the state regulatory authority and OSM will jointly review mining and permit applications. Both agencies will recommend approval or disapproval to the officials of the state and Department of the Interior authorized to take final actions on the permit.

Bureau of Land Management (BLM)

BLM develops special requirements to be included in the reclamation plan concerning management and protection of all resources other than coal and the postmining land use of the affected lands. BLM is also responsible for granting various rights-of-way for ancillary facilities on public lands.

U.S. Geological Survey (USGS)

USGS is responsible for development, production, and coal resource recovery requirements included in the mining permit.

State of Wyoming, Department of Environmental Quality (DEQ)

Whenever Wyoming enters into a cooperative agreement with the Secretary of the Interior, pursuant to Section 523(c) of SMCRA, DEQ and OSM will jointly review and act on the mining and reclamation plan and permits to mine authorized under a federal coal lease.

The Land Quality Division of DEQ issues permits and licenses to mine according to the approved mining and reclamation plan. The Air Quality Division issues permits for construction and operation after review of applications with regard to air contaminants and plans for control and monitoring. The Water Quality Division issues permits to construct water systems. The Solid Waste Division issues construction fill permits and industrial waste facility permits for solid waste disposal during construction and operation.

Wyoming State Engineer

Use of surface or groundwater for mining and coal processing operations requires a permit from the State Engineer. Permits are also necessary prior to installation of wells, the use of mine inflow waters, and construction of water pipelines.

INTERRELATIONSHIPS

Relationship to Land Use Plans

Bureau of Land Management (BLM)

The Management Framework Plan (MFP) for the Eastern Powder River Basin, as updated in 1977, recommends the management of mineral resources for efficient development, giving priority consideration to energy minerals. At the same time, it considers environmental protection and mitigation of socioeconomic impacts.

Planning recommendations specific to the proposed Buckskin Mine were not addressed in the MFP since the coal is under an existing federal lease issued in 1967.

Gillette/Campbell County

The City of Gillette/Campbell County Planning Department, formed in 1968, completed a draft comprehensive plan in 1977. Among other provisions, the plan proposes countywide monitoring of surface coal mining for conformance to the plan, in order to control the rate and location of development in the county. BLM land use planning would consider the recommendations of this plan; however, specific applications of this draft plan have not been made to the proposed Buckskin Mine.

Relationship to Other Proposed and Future Actions

The proposed Buckskin Mine would supply 2% of the 173 million tons of coal to be mined in the region in 1990 under the probable level of development, as discussed in the regional part of this document. The 400 additional unit trains of coal per year would constitute 2.5% of the projected 15,697 unit trains that would leave the region from all mines annually by 1990.

Other active and approved mines in the Gillette area would cause competition for housing, services, and the available labor supply; would increase rail traffic, dust, and water usage; and would increase the demand on transportation and communication networks.

Reference is made to the analysis included in the regional part of this environmental statement for a full discussion of the interrelationship between the Buckskin Mine and other mines in the region.

CHAPTER 2

DESCRIPTION OF THE ENVIRONMENT

INTRODUCTION

This chapter consists of two parts: existing environment and future environment. It describes the physical, biological, and cultural factors which constitute the environment at the proposed Buckskin Mine site. The description of the existing environment emphasizes those environmental factors most likely to be affected by the proposed action. The description of the future environment focuses on the same environmental factors as they would exist in 1980, 1985, and 1990, and at the end of mine life without approval of the proposed action. These descriptions provide a base for the analysis in Chapter 3, "Environmental Impacts of the Proposed Action,"since alteration of these environmental factors would result if approval were to be granted.

CLIMATE

The climate of Campbell and Converse counties is characterized by dry air masses, which are modified Pacific air masses that move eastward over the Rocky Mountains. The Big Horn Mountains, part of the Rocky Mountain chain, lie about 60 miles west of the proposed Buckskin Mine site. Most of the region's precipitation falls from these air masses, but some precipitation results from incursions of moist air from the Gulf of Mexico. In the summer, most of the precipitation in the region is provided by thunderstorms. The prevailing winds are south-southeasterly and south-southwesterly. Northerly winds are also common.

The proposed Buckskin Mine site, about 10 miles north of Gillette, is located in an area of gently rolling hills. Temperatures at the site average 44°F annually with an average of 22°F in January and 72°F in July. Maximum temperatures of 90°F or above occur in July, while January is the coldest month with a frequent daily mininum temperature of 0°F or below. The average growing season (32°F or above) at the site is estimated to be 129 days. The area receives about 14 inches of precipitation annually (National Oceanic and Atmospheric Administration 1974).

Theoretical calculations indicate that at any point in the Eastern Powder River Basin the mean recurrence interval for a rainfall rate of 1.7 inches in a 30-minute period is 100 years. Similarly, 24-hour rainfalls of 4 inches can be expected once every 100 years (Hershfield 1961). It may be assumed that these occurrences have the same probability at the Buckskin Mine site.

Precip - ±15, 6" p.a.

Statistical analysis of long-term data for Douglas, Gillette, and Dull Center indicates that 1-year drought periods occur once every 7 years; 2-year drought periods occur once every 25 years; and 3-year drought periods occur once every 143 years. For further details, refer to Chapter 2, Climate, in the Regional Environmental Statement.

Wind speeds are out of the south for much of the year and average about 9 miles per hour. Figure BU2-1, a wind rose for Moorcroft, Wyoming, is considered representative of wind patterns on the Buckskin site. Stable atmospheric conditions prevail about 60% of the time because of the cool temperatures and moderately strong winds (Hosler 1961). Surface-based inversions occur on 75% of the mornings, being most frequent in summer (84%) and least in winter (60%). They occur only 18% of the time in the afternoon, being most frequent in winter (41%) and least in spring (5%). The mean annual lake evaporation is about 36 to 42 inches.

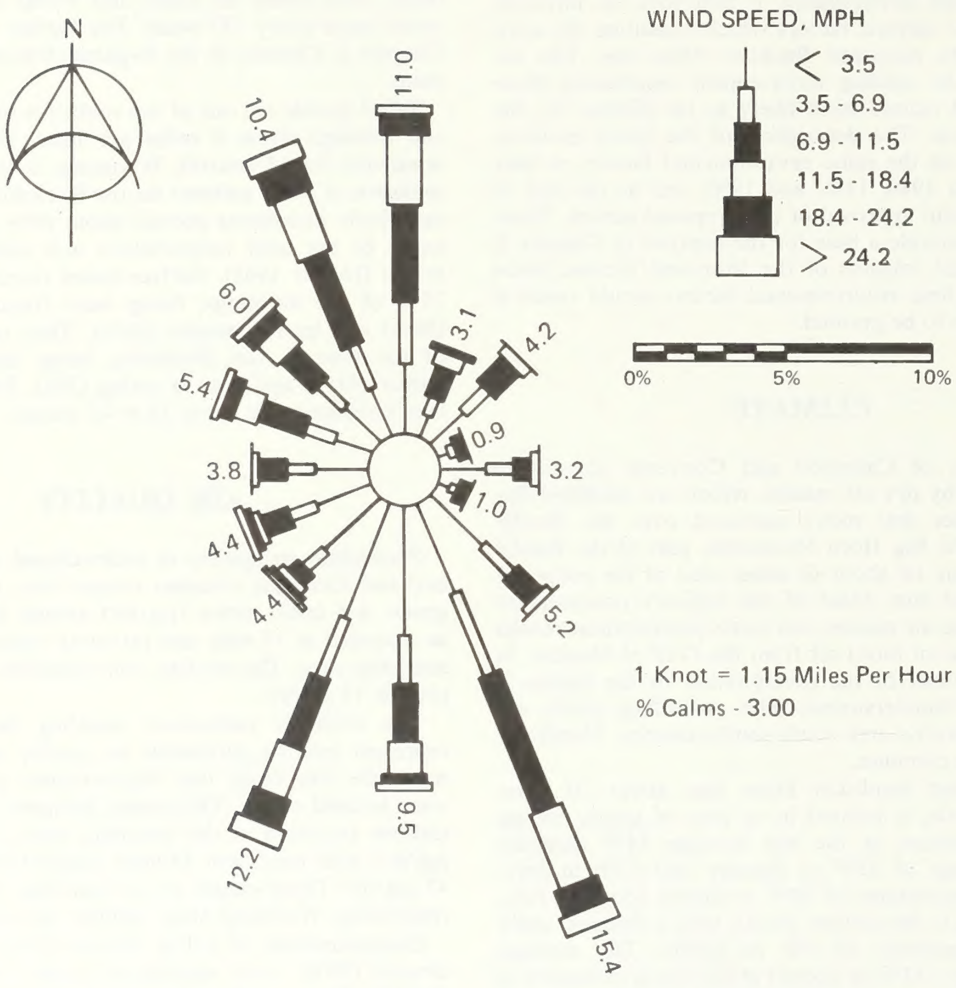
AIR QUALITY

Particulate air quality in undeveloped areas of Campbell and Converse counties ranges from 11 to 31 micrograms per cubic meter ($\mu g/m^3$) annual geometric mean as recorded at 17 state and privately operated particulate sampling sites. The median concentration at the 17 samplers is 19 $\mu g/m^3$.

The available particulate sampling data which best represent existing particulate air quality at the proposed mine site are from two high-volume samplers which were located onsite. The annual geometric mean concentrations recorded at the sampling sites were 11 and 12 $\mu g/m^3$, with maximum 24-hour concentrations of 44 and 47 $\mu g/m^3$. These values are all less than 20% of the corresponding Wyoming state ambient air quality standard.

Concentrations of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) were sampled at a site 7 miles south of Gillette. The annual arithmetic means recorded in 1976 for SO_2 and NO_2 were 13 $\mu g/m^3$ and 19 $\mu g/m^3$ respectively (Wyoming Department of Environmental Quality 1977), both of which are far below the Wyoming state standards. No measurements of carbon monoxide or hydrocarbons were taken.

Visibility at the site ranges from less than 1 mile to greater than 60 miles throughout the year. The primary causes of low visibility are fogs, haze, dust, and blowing snow. Average monthly visibility ranges from about 26



SOURCE: NATIONAL CLIMATIC CENTER, 1950-1952, 1968

Figure BU2-1

ANNUAL WIND ROSE FOR THE PROPOSED BUCKSKIN MINE SITE

to 47 miles, with greatest visibility occurring during spring and summer months.

TOPOGRAPHY

The proposed mine site lies within the Upper Missouri Basin of the Northern Great Plains physiographic province (Fenneman 1931); it is characterized by low, rolling hills dissected by intermittent drainages. In the northern part of the site, the land slopes gently southward, and in the southern part gently northward into Rawhide Creek, the main drainage. Rawhide Creek is an intermittent stream which flows from west to east across the southern part of the site. Spring Draw, the main tributary of Rawhide Creek in the lease area, is also intermittent. It flows from northwest to southeast and joins Rawhide Creek along the southeast edge of the lease. Two intermittent internal drainage systems which terminate in playas are present along the western boundary of the lease, and two more are present within the 1,000-foot perimeter (Figure BU2-2). The highest point of elevation on the lease is about 4,260 feet in the northeast corner, and the lowest point, 4,110 feet, is on the southeast boundary where Rawhide Creek exits the property. A physiographic diagram illustrating generalized topography of the lease is shown in Figure BU2-3. Figure BU2-2 is a detailed topographic map of the mine site.

GEOLOGY

The proposed mine site is located on the gently (generally less than 2°) southwest dipping east flank of the Powder River Basin.

Geologic formations that are exposed in the lease area are the Paleocene Fort Union Formation, the Eocene Wasatch Formation, and Quaternary alluvium. (See Regional Environmental Statement, Figure R2-7, for rock and geologic time sequences.)

There is some disagreement as to the exact location of the Fort Union-Wasatch boundary, but for purposes of this statement, it is considered to be at the top of the coal. The Fort Union Formation, below the coal, consists of brown and dark gray to black carbonaceous shale and siltstone interbedded with light gray, fine-grained, friable sandstone and thin coal beds. The Anderson-Canyon (Wyodak) coal bed, which is to be mined, is at the top of the Fort Union Formation and averages 104 feet in thickness in the lease area. The Wasatch Formation above the coal consists of shale, sandy shale, and soft lenticular sandstone. It varies from 20 to 215 feet in thickness.

Quaternary deposits consist of colluvium (weathered bedrock) and unconsolidated clay, silt, sand, and gravel alluvium along streams. Some of the Quaternary units are wholly or partially within the definition of alluvial valley floors (Surface Mining Control and Reclamation Act) as shown on the geologic map (Figure BU2-4). Scoria (clinker) is present in many places where the coal seam is exposed; it is the result of baking and collapse of the enclosing rock when portions of the coal seam burned, probably during early Quaternary (Pleistocene) time. Scoria, colluvium, and alluvium generally mask the outcrop of the coal seam, but the approximate edge of the coal is shown on Figure BU2-4.

According to the environmental analysis provided by the applicant, the area is geologically stable with no faulting or extensive folding, and there is no evidence of landsliding or stratigraphic instability. Geological stability is a regional characteristic.

Paleontology

The proposed Buckskin site was surveyed for paleontological resources and assessed for its potential by Paul O. McGrew, Department of Geology, University of Wyoming, in 1976. He reported the following results (personal communication 1977). No fossil localities are known from the lease area. Fossil leaves and invertebrates which occur fairly abundantly throughout the Fort Union and Wasatch formations likely would be encountered at the Buckskin site. No significant vertebrate fossils have ever been found in the Fort Union Formation of the Powder River Basin, and vertebrate fossils from the Wasatch Formation are quite rare and known from only a few isolated localities. Some of these forms could be encountered at the Buckskin site. McGrew assessed the possibilities of encountering fossil mammals in the lease area as remote for the Fort Union Formation and very low for the Wasatch Formation.

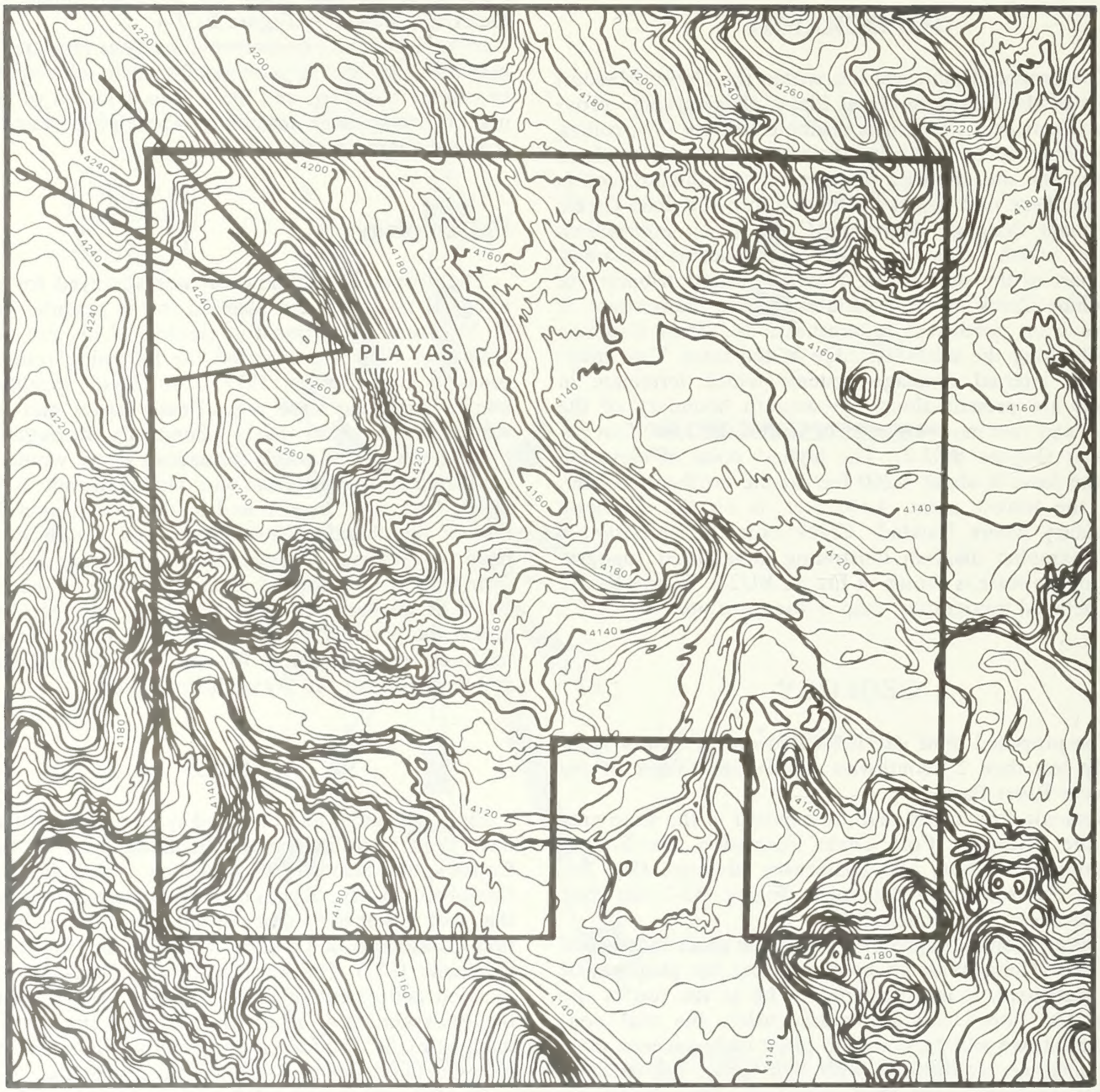
SOILS

Eight soil series and one land type, rough broken land, have been identified on the Buckskin lease by the Soil Conservation Service (SCS) in their 1955 Soil Survey of Campbell County, Wyoming. These were correlated with the most recent soil survey of the area by Mine Reclamation Consultants of Laramie, Wyoming in 1976 (Shell Oil Company 1977). The soil map (Figure BU2-5) shows the location and extent of different kinds of soil located on the Buckskin lease. The proposed mine site is being remapped by SCS; information given on Figure BU2-5 and below may change as a result of the remapping.

The following are brief descriptions of the soils on the lease area. A technical soil profile description of each soil series is shown in the Appendix. More interpretive information on each soil series below is in Table RB-1, Appendix B of the Regional Environmental Statement (ES).

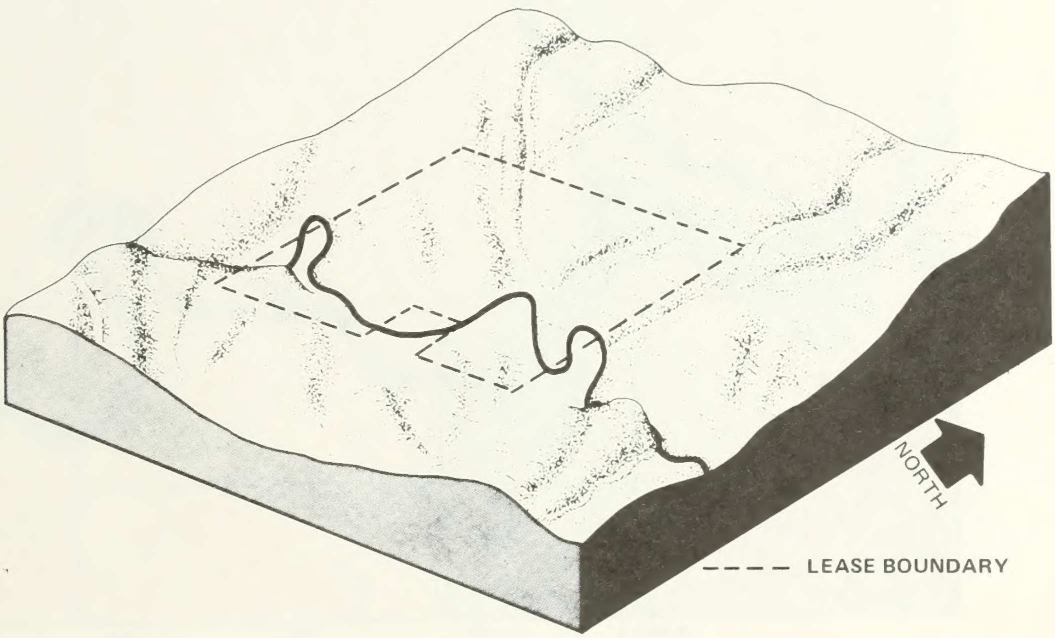
Arvada Series. The Arvada series consists of deep, well-drained, fine-textured, alkaline-rich soils forming on level to undulating alluvial fans and topslopes. Topsoil potential is poor because of high clay content and high alkaline content.

Bankard Series. The Bankard series consists of deep, well-drained, coarse-textured soils forming on alluvial valley floors on low terraces adjacent to streams. Topsoil



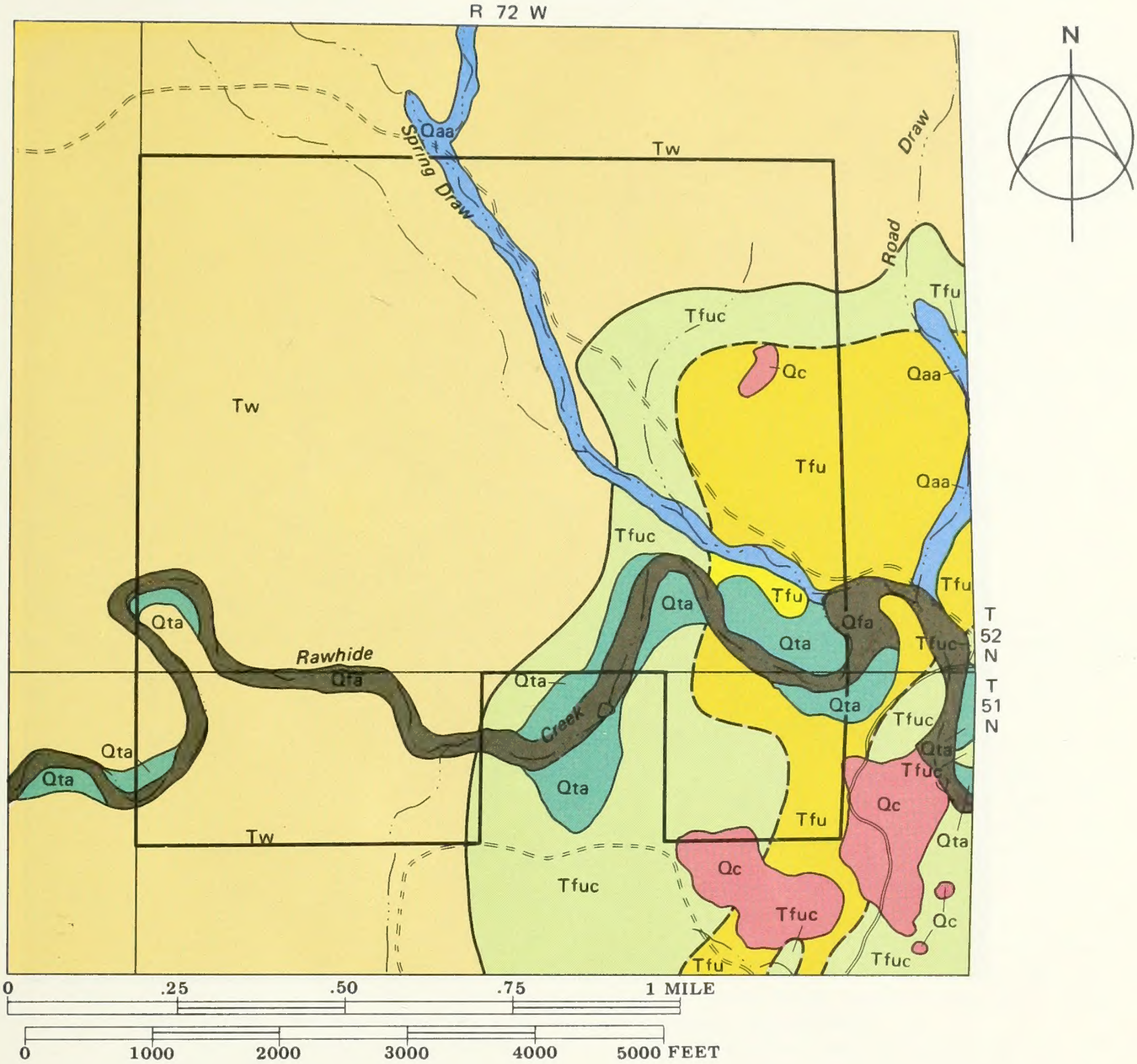
Contour Interval = 4 feet

Figure BU2-2
TOPOGRAPHIC MAP OF THE BUCKSKIN MINE AREA



SOURCE: ECOLOGY CONSULTANTS 1977

Figure BU2-3
GENERALIZED TOPOGRAPHY OF THE PROPOSED BUCKSKIN MINE AREA



LEGEND

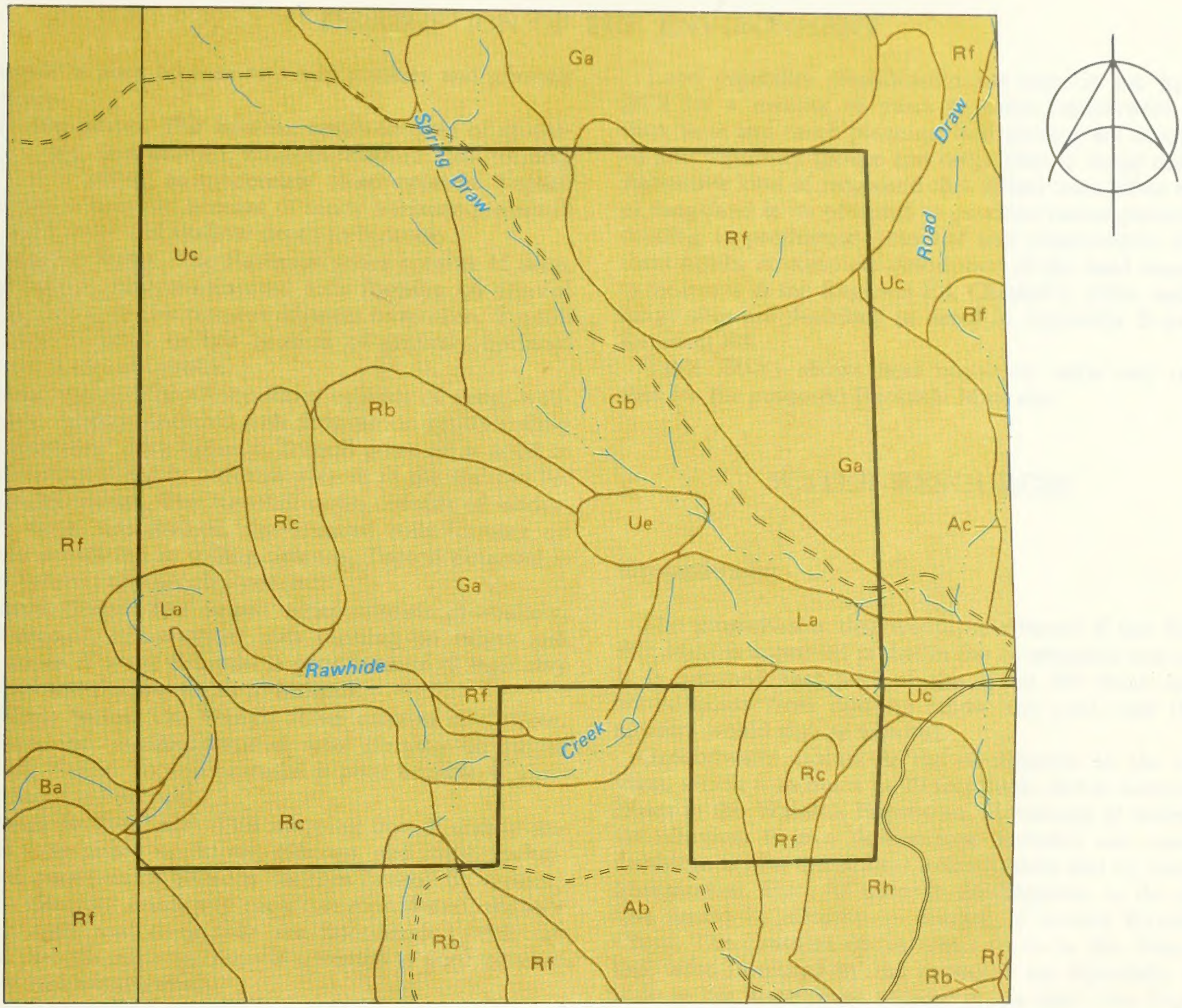
Qfa	FLOODPLAIN ALLUVIUM
Qta	LOW TERRACE ALLUVIUM
Qaa	FLOODPLAIN AND TERRACE ALLUVIUM OF MINOR STREAMS
Qc	SCORIA
Tw	WASATCH FORMATION
Tfuc	FORT UNION COAL (WYODAK SEAM)
Tfu	FORT UNION FORMATION
———	TOP OF COAL
— — —	BASE OF COAL

NOTE:

1. Top and base of Wyodak Coal Seam interpreted from Shell Oil Company, 1977.

2. Qfa is within the definition of alluvial valley floors according to the Surface Mining Control and Reclamation Act of 1977 (SMCRA). Qta and Qaa are included, but must be studied in greater detail to determine how much of their area falls within the SMCRA definition. Williams in press.

Figure BU2-4
GEOLOGIC MAP OF BUCKSKIN MINE SITE



LEGEND

Ab Ac	ARVADA SERIES
Ba	BANKARD SERIES
Uc,Ue	BOWBAC SERIES
La	HAVERSON SERIES
Ga,Gb	OLNEY SERIES
Rb,Rc	RENOHILL SERIES
Rh,Rf	SAMSIL - SHINGLE - ROCK OUTCROP

SOURCE: Soil Survey of Campbell, County, Wyoming, July, 1955 with modifications from Shell Oil Company, 1977.

Figure BU2-5
SOILS MAP OF BUCKSKIN MINE SITE

potential is poor because of sandy textures and gravelly horizons.

Bowbac Series. The Bowbac series consists of moderately deep, well-drained, medium-textured soils forming on gently rolling to moderately steep uplands. Topsoil potential is only fair because of sandy horizons present in the soil profile and shallow depth to bedrock.

Haverson Series. The Haverson series consists of deep, well-drained, medium-textured soils forming on alluvial valley floors on low terraces adjacent to streams. Topsoil potential is good to fair because of gravelly horizons present in the soil profile.

Olney Series. The Olney series consists of deep, well-drained, medium-textured soils forming on gently rolling to moderately steep uplands. Topsoil potential is good to fair because of sandy horizons present in the soil profile.

Renohill Series. The Renohill series consists of moderately deep, well-drained, fine-textured soils forming on gently undulating to rolling uplands. Topsoil potential is poor because of high clay content.

Samsil Series. The Samsil series consists of shallow, well-drained, fine-textured soils forming on ridges and hill slopes. Topsoil potential is poor because of high clay content and shallow depth to bedrock.

Shingle Series. The Shingle series consists of shallow, well-drained, medium-textured soils forming on ridges and hill slopes. Topsoil potential is poor because of shallow depth to bedrock.

Rough Broken Land. This mapping unit is mainly derived from mixed sandstone, siltstone, and shale. Included are escarpments between benches formed by erosion, badly dissected areas, and rock outcrops. Small, shallow stony areas and deep soils are intermingled with the areas of rock outcrop. Topsoil potential is poor because of the variable materials.

Land capability classification refers to a grouping of kinds of soils into special units according to their capability for intensive use and the treatments required for sustained use. This classification system has been prepared by the SCS (1973), which recognizes eight classes of land according to the risk of land damage or the difficulty of land use. Four of these classes are present on the proposed Buckskin Mine site:

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both. Generally the last soil grouping considered suitable for cultivated crops; requires major treatment.

Class VI. Soils that have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture, or range, woodland, or wildlife food and cover.

Class VII. Soils that have very severe limitations that make them unsuitable to cultivation and that restrict their use largely to grazing, woodland, or wildlife food and cover.

Class VIII. Soils and landforms that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or aesthetic purposes. Generally, Class VIII soils do not respond to management treatment within agricultural purposes.

Land capability classification has been in use by the SCS for a number of years to assist landowners with their farm and ranch planning. Soil surveys are interpreted into capability groups and range sites (a range site is a distinctive kind of rangeland that differs from other kinds of rangeland in its potential to produce native plants) according to production potential and conservation treatment needs. A complete description of the land capability system is in the Regional ES, Chapter 2, Soils, and the range sites are described in detail in Appendix B of the Regional ES.

Table BU2-1 shows land capability units and range sites for the proposed Buckskin Mine site.

WATER RESOURCES

Groundwater

The groundwater that would be affected if the Buckskin Mine is approved is that in the overburden and coal. It is assumed that part of the water for mine usage would come from aquifers below the coal, and these aquifers would also be affected.

Groundwater occurs in the overburden in the alluvium, which is as much as 20 feet thick, and in sandstone lenses in the Wasatch Formation. Movement of water in the alluvium is in a downstream direction and natural discharge is into the surface water system and by evapotranspiration. Flow of water in the Wasatch, in the area that would be affected by mining, is toward Rawhide Creek. The contours of the water levels in the Wasatch that were furnished by the applicant are essentially the same as the water level contour in the coal. (See Figure BU2-6.) Natural discharge is by springs, evapotranspiration, and into the alluvium.

The applicant, in summarizing the aquifer properties, stated the alluvium could transmit an average of about 8,000 gallons per day through each foot of aquifer width when the hydraulic gradient is 1:1 (gpd/ft.), and the sandstone could transmit about 5,000 gpd/ft. The storage coefficient, which is the volume of water released from, or taken into, storage per unit decline in head per unit surface area of the aquifer, is about 0.05 for the alluvium and in the order of 0.05 for the sandstone.

The contour map of water levels in the coal (Figure BU2-6) indicates the mine site is in an area where water is being discharged from the coal toward Rawhide Creek where it is discharged into the alluvium. The applicant states the coal will transmit an average of about 2,000 gpd/ft. of water and that the storage coefficient is about 0.0006.

The chemical quality of the water from the alluvium, overburden, and coal at the leasehold is similar to that elsewhere in the region. One set of analyses furnished by the applicant is given in the Appendix. The locations of the sampling sites are shown in Figure BU2-7.

Hydrologic information provided by Shell Oil and given above correlates with other data collected in the region.

TABLE BU2-1

SOILS, LAND CAPABILITY UNITS, AND RANGE SITES AT PROPOSED BUCKSKIN MINE SITE

Soils	Land Capability	Range Site
Arvada	VIs	Saline lowland
Bankard	IVe	Lowland
Bowbac	VIe	Sandy
Haverson	IVe	Lowland
Olney	VIe	Sandy
Renohill	VIe	Clayey
Rough Broken Land	2/3 VIIe 1/3 VIIIs	1/3 Shallow loamy 1/3 Shallow clayey 1/3 Rock outcrop
Samsil	VIIe	Shallow clayey
Shingle	VIIe	Shallow loamy

Subclasses are groups of capability units which have the same major conservation problem.

s - special soil characteristic such as root-zone limitations or excess salts

e - erosion and runoff

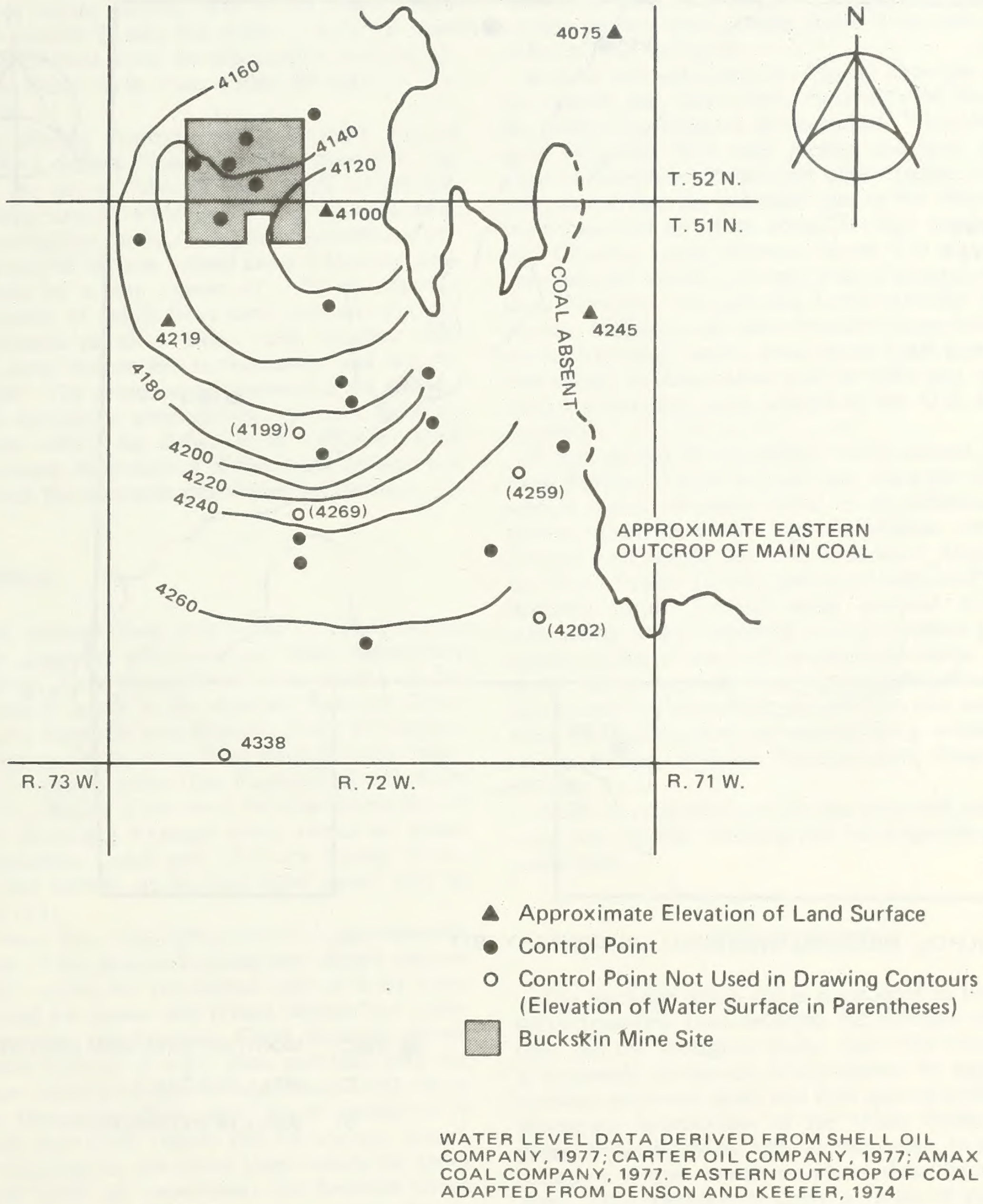
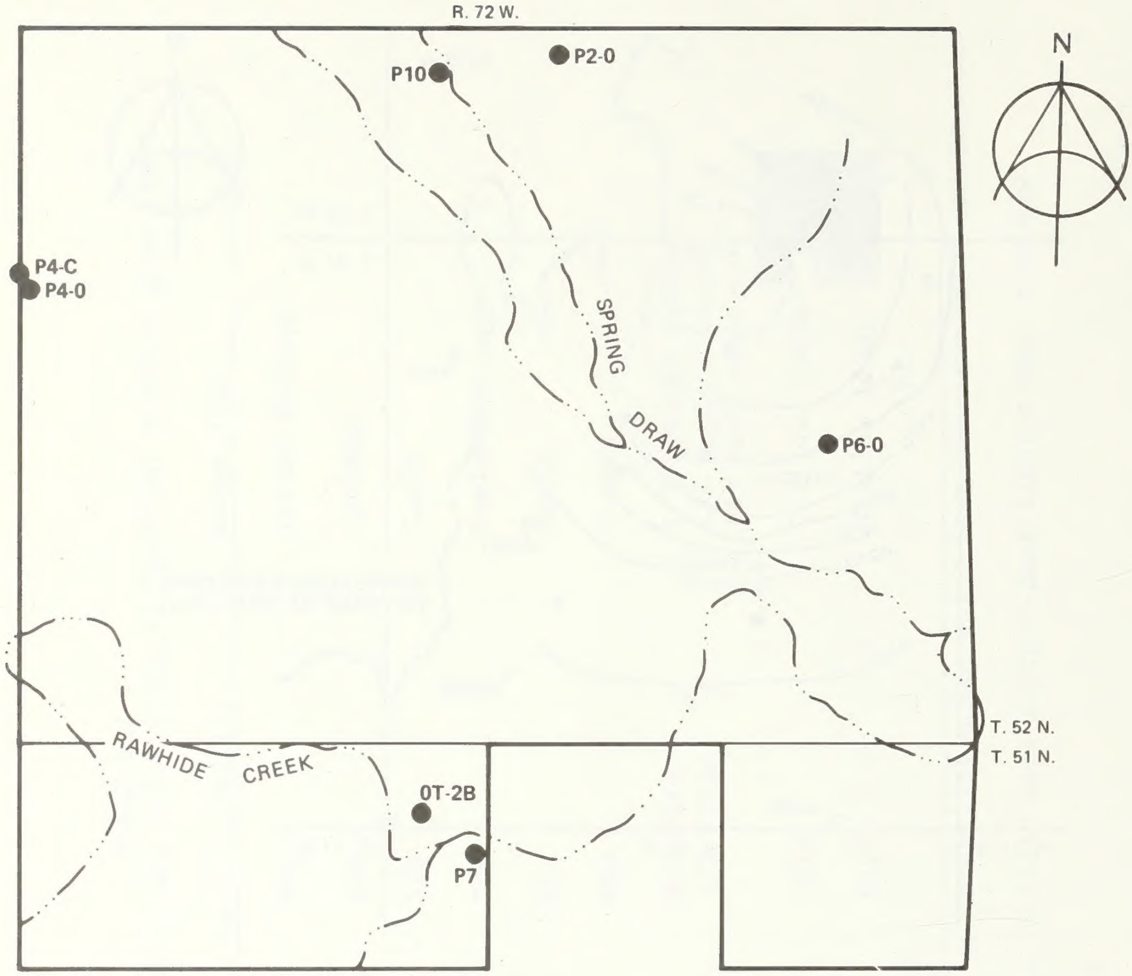


Figure BU2-6

CONTOUR MAP OF WATER LEVELS IN THE COAL



SOURCE: MODIFIED FROM SHELL OIL COMPANY 1977

●	P2-C	MONITOR WELL AND IDENTIFIER
	C	WELL IN COAL
	0	WELL IN OVERBURDEN

Figure BU2-7

LOCATIONS OF WELLS ON THE BUCKSKIN LEASE FOR WHICH CHEMICAL ANALYSES ARE GIVEN IN APPENDIX

Excluding wells drilled by the applicant, there are 6 wells inside or within one-half mile of the lease. There are 46 wells outside ½ mile but within 3 miles of the lease. Twenty of these wells are observation wells at adjoining mines. Other wells were drilled for stock or domestic supplies.

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) defines "alluvial valley floors"for the purposes of the act as "the unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation and windblown deposits" The presence of unconsolidated stream-laid deposits containing groundwater indicates hydrologic conditions within the definition of "alluvial valley floors"are present. Strip mining of the floors would have to comply with the standards established by SMCRA.

Surface Water

Ephemeral streams (flow as a result of precipitation) entering the proposed mine area are both intermittent and interrupted (flow for parts of most years and for short distances at points in the streams). Rawhide Creek enters the area from the west draining about 69.1 square miles, and Spring Draw enters from the northwest draining about 2.13 square miles. (See Regional Environmental Statement, Chapter 2, for more detailed description of streams and drainage.) Average valley slopes are about 0.3% for Rawhide Creek and 1.2% for Spring Draw. Maximum land surface slopes vary from about 70% to about 100% (1:1).

Surface water flow originating from the approximately 1 square mile of the proposed mining area should amount to about 0.031 cubic feet per second (cfs) or 0.031 cubic feet per second per square mile (cfsm). Streamflow entering the area from the Rawhide Creek drainage should average about 0.80 cfs or 0.012 cfsm, and that from the Spring Draw drainage should average about 0.045 cfs or 0.021 cfsm. Peak streamflows with return periods of 10 years and 25 years (10% chance and 4% chance, respectively, of occurring in any given year) should be about 1,400 cfs and 2,300 cfs respectively for Rawhide Creek and about 400 cfs and 600 cfs respectively for Spring Draw. (Peak flow data was derived from U.S. Department of the Interi¬r 1977, Hodson et al. 1973, and Lowham 1976). Stream slopes are about 0.2% for Rawhide Creek and about 1.1% for Spring Draw; the sinuosities (as measured b› the ratio of stream length to valley length) for the two .teams are about 1.3 and 1.1 respectively. Flood veloc.ties should vary from about 3 feet per second (fps) to about 5 fps in Rawhide Creek and from about 4 fps to ..bout 7 fps in Spring Draw.

There is only ab‹›ut ½ mile of main channel in the proposed lease area which could possibly contain point sources of intermitt :nt flow. Reconnaissance September 30, 1977, indicated water in 0.2 to 0.3 miles of channel. There are about 6 wells and 5 reservoirs, irrigation diversion ditches, and spreader dams in the area (data furnished by the applicant).

Erosion and sedimentation depend upon the energy of the rainfall and water flow, erodibility of the soil, and the protective influence of vegetation. Water-borne sediment originates from sheet erosion and from gulley and channel formation. Shown and others (report in preparation) found that the sediment rate in the vicinity of the mine (based on data from about 20 ranch ponds in Campbell County) varied between about 0.01 to about 0.25 acre-feet per square mile per year. Sediment concentrations from adjoining streams, Little Missouri River near Alzada, Montana and Belle Fourche River below Moorcroft, Wyoming, varied from about 2,000 parts per million (ppm) to about 4,000 ppm in 1949 and 1950 (from annual streamflow data reports of the U.S. Geological Survey).

Water quality investigations from several wells and from Rawhide Creek indicate that the water in the lease area is typical of water found in the Gillette area, i.e., highly mineralized, too high for human consumption. Several well samples showed some trace elements above the U.S. Public Health Service's suggested limits for drinking water. Surface water samples showed that streamflow had a dissolved oxygen content lower than expected; that it was high in dissolved solids; and that it could be characterized as magnesium/sodium/ sulfate type water. (Water quality information was derived from Shell Oil's mining and reclamation plan, which is on file at the Bureau of Land Management's Casper District Office.)

Water is presently used on the proposed mine site for stock and wildlife watering and for irrigation of hay and grain fields.

VEGETATION

The Buckskin Mine site is considered to be in a vegetative transition zone between the northern desert shrub type and the shortgrass plains type. The transition zone is frequently dominated in appearance by sagebrush, but contains numerous grass and forb species common to the shortgrass communities of the Great Plains. The proposed Buckskin Mine site, in particular, is more representative of true shortgrass plains than the surrounding areas. This condition is likely a result of past management practices which prevented serious overgrazing of the property.

Terrestrial Vegetation

As shown in Chapter 1, the Buckskin permit area consists of a main mining area, a railroad route, and access roads. The acreages of all these areas are included in the following discussion. The vegetation map, however, is confined to the main mining area (lease plus 1,000-foot perimeter).

DESCRIPTION OF THE ENVIRONMENT

The following information was derived from the applicant's mining and reclamation plan. Five primary vegetation types exist on the Buckskin Mine permit area: playa grassland, sandhills grassland, big sagebrush, silver sagebrush, and riparian. In addition to these types, there is some scattered cultivated land on the mining area.

The vegetative types within the proposed mining area have been delineated in Figure BU2-8; they are described in the following paragraphs, and are keyed to the map.

Playa Grassland Type (map symbol 1A) 5 acres

This vegetation type covers the smallest portion of the total permit area. Vegetation of the playa type is dominated by grasses and grasslike species. Important species found here are western wheatgrass *(Agropyron smithii)*, Kentucky bluegrass *(Poa pratensis)*, rush *(Juncus* spp.) and sedges *(Carex* spp.). Common dandelion *(Taraxacum officinale)* and Louisiana sagewort *(Artemisia ludoviciana)* are also found in this vegetation type.

Sandhills Grassland Type (map symbol 1C) 298 acres

Grasses and forbs predominate in this vegetation type, comprising approximately 81% of the vegetative cover. Prairie sandreed *(Calamovilfa longifolia)*, needle-and-thread *(Stipa* comata), blue grama *(Bouteloua gracilis)*, and prairie *junegrass (Koeleria cristata)* are the common grasses. Forbs and shrubs include silverleaf scurfpea *(Psoralea agrophylla)*, hairy goldenaster *(Heterotheca villosa)*, fringed sage *(Artemisia* frigida), and silver sagebrush *(Artemisia cana)*.

Big Sagebrush Type (map symbol 4) 662 acres

This vegetation type is the most extensive on the Buckskin permit area and is characterized by the presence of big sagebrush *(Artemisia tridentata)* as the predominant shrub. Grass and grasslike species of primary importance include western wheatgrass, blue grama, needle-and-thread, prairie junegrass, and threadleaf sedge *(Carex filifolia)*. Other common species are Hood's phlox *(Phlox hoodii)*, *milkvetch (Astragalus* spp.), broom snakeweed *(Gutierrezia sarothrae)*, fringed sage, and silver sagebrush.

Silver Sagebrush Type (map symbol 4A) 478 acres

A predominance of grasses interspersed with clumps of silver sagebrush characterizes this vegetation type on the permit area. The most important grass and grasslike species are needle-and-thread, blue grama, western wheatgrass, and threadleaf sedge. Important forbs and shrubs are scarlet globemallow *(Sphaeralcea coccinea)*, and fringed sage. Plains pricklypear cactus *(Opuntia polycantha)* is found infrequently in sandy depressions.

Riparian Type (map symbol 10) 148 acres

Total vegetative cover is highest in this vegetation type (62.6%), with grasses making up 57% of the total. Important grasses are Kentucky bluegrass, prairie cordgrass *(Spartina* pectinata), and inland saltgrass *(Distichlis spicata)*. Other common species include sedges, baltic rush *(Juncus balticus)*, and yellow sweetclover *(Melilotus officinalis)*. The vegetation of Rawhide Creek is indicative of an alluvial valley floor.

Cultivated Lands (map symbol 19) 169 acres

The scattered cultivated lands comprise approximately 10% of the total lease and perimeter area. The primary species occurring in this area is intermediate wheatgrass *(Agropyron* intermedium). This area is generally harvested for hay each summer. Some barley and wheat are also grown. (See Chapter 2, Agriculture.)

Aquatic Vegetation

Rawhide Creek flows during periods of snowmelt in the spring and after summer thunderstorms. During the remainder of the year, surface water in Rawhide Creek consists of isolated pools of perhaps 100 square feet or less with depths of 2 to 6 inches. Aquatic vegetation is limited to species which require wet ground, but which can exist for long periods without standing water, as in valleys with subirrigated alluvium. Main species observed in Rawhide Creek include bulrush *(Scirpus* spp.), common cattail *(Typha latifolia)*, sedges, watercrowfoot *(Ranunculus aquatilis)*, and filamentous green algae. The predominant species observed was watercrowfoot which completely filled the pools.

Temporary surface water exists in the playas near the west lease boundary. Each playa drains less than 40 acres. Semiaquatic vegetation in the playas consists primarily of sedges. Aquatic flora is probably limited to a few species of algae.

Endangered and/or Threatened Species

No plants which have been identified as threatened or endangered, or are proposed for such designation, have been found on the proposed mining area (Shell Oil Company 1977). A plant specialist from the Wyoming Department of Environmental Quality has conducted a survey, at the request of the Bureau of Land Management, and has verified the applicant's conclusion (personal communication 1978).

FISH AND WILDLIFE

The Wyoming Game and Fish Department, under contract with the Bureau of Land Management, is presently studying wildlife distribution and density in the

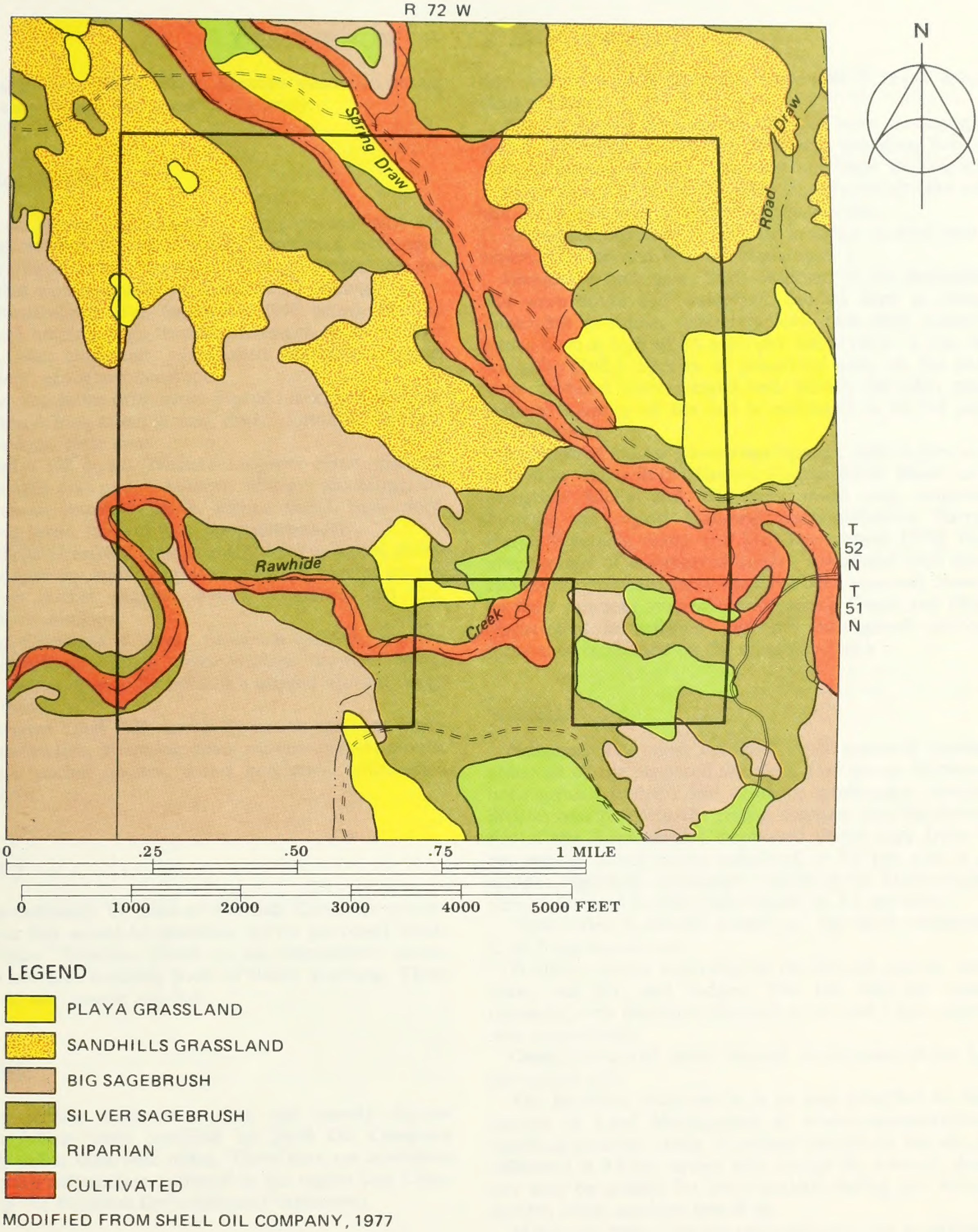


Figure BU2-8

GENERAL VEGETATION MAP OF BUCKSKIN MINE SITE

Eastern Powder River Basin. Density estimates shown below may change as a result of the study.

Habitat Types

The six habitat types found on the proposed mine site and the wildlife species normally associated with each type are listed below. Acreages shown in parentheses are those that would actually be disturbed by mining.

Sagebrush-Grass (Big Sagebrush) (447 acres). Horned lark, lark bunting, sage thrasher, Brewer's sparrow, deer mouse, least chipmunk, white-tailed jackrabbit, coyote, mule deer, pronghorn antelope.

Silver Sagebrush (278 acres). Horned lark, lark bunting, deer mouse, long-tailed weasel, desert cottontail, pronghorn antelope, mule deer.

Riparian (72 acres). Western kingbird, robin, mallard, blue-winged teal, pintail, killdeer, Wilson's phalarope, vagrant shrew, muskrat, mink, striped skunk, mule deer, snapping turtle, leopard frog, tiger salamander.

Sandhills Grassland (149 acres). Vesper sparrow, grasshopper sparrow, mourning dove, western harvest mouse, northern pocket gopher, desert cottontail, red fox, pronghorn antelope.

Playa Grassland (4 acres). Savannah sparrow, western meadowlark, mourning dove, western harvest mouse, hispid pocket mouse, Richardson's ground squirrel, long-tailed weasel.

Cultivated Land (121 acres). Savannah sparrow, western meadowlark, mourning dove, western harvest mouse, northern pocket gopher, desert cottontail, white-tailed jackrabbit.

Fishery

Approximately 1½ miles of Rawhide Creek lie within the area that would be disturbed by the proposed Buckskin Mine. Rawhide Creek is an intermittent stream which contains standing pools of water yearlong. These pools do not contain any fish.

Wildlife

The wildlife observation data and density figures which follow were provided by Shell Oil Company (1977), unless otherwise noted. These data are consistent with other information gathered in the region (see Chapter 2 of the Regional Environmental Statement).

Birds

Nongame. The primary nongame bird species observed on the proposed Buckskin site were vesper sparrow, grasshopper sparrow, lark bunting, western meadowlark, brown-headed cowbird, red-winged blackbird, and Brewer's blackbird. Results of other studies, in wildlife habitat types similar to those on the site, indicate songbird density is 1,005 birds per square mile (1.57 per acre) (Oakes 1976).

Raptor species observed on the site were Swainson's hawk, American kestrel, marsh hawk, red-tailed hawk, and ferruginous hawk. There has not been any raptor nesting observed on the Buckskin site. Raptor density on the site is estimated to be 4.8 per square mile.

Shorebirds observed on the site included spotted sandpipers, killdeer, and Wilson's phalaropes.

Game. The only game birds observed on the Buckskin site were doves and waterfowl. Studies done at other mine sites in similar habitat indicate that dove density varies from a high of 25 pairs per 100 acres to a low of 2.3 pairs (ibid.). Species of waterfowl seen on the site were blue-and green-winged teal, pintail, shoveler, and mallard. Density of the last is estimated to be 6.6 per square mile.

Endangered and/or Threatened Species. Bald eagles are known to winter in the Eastern Powder River Basin, and peregrine falcon and whooping crane may migrate through the region (personal communication, Harry Harju, Wyoming Game and Fish Department 1978). No observations of endangered and/or threatened bird species on the proposed mine site have been reported. Based on their previous studies, the Wyoming Game and Fish Department is satisfied that no endangered and/or threatened birds exist on the mine site (ibid.).

Mammals

Nongame. The most common small mammal species observed on the proposed site were deer mouse, thirteen-lined ground squirrel, and northern grasshopper mouse. Studies conducted in the region estimate that the densities of the three species mentioned above vary from 2 per acre in mixed prairie grassland, to 5.7 per acre in a sprayed sagebrush community (Oakes 1976). The average density for both habitat types would be 3.8 per acre.

White-tailed jackrabbit density on the site is estimated to be 5 per square mile.

Predator species occurring on the site are coyote, raccoon, red fox, and badger. The last two are most common, with densities estimated at 0.4 and 1 per square mile respectively.

Game. Cottontail rabbit density is estimated to be 3.3 per square mile.

The Buckskin Mine site is in an area classified by the Bureau of Land Management as winter-concentration-yearlong antelope range. Antelope density on the site is estimated at 9.8 per square mile during the summer; density may be greater for short periods during the winter months when antelope bunch up.

Mule deer density on the proposed mine site is estimated at 1 per 2 square miles. Mule deer numbers should not be subject to seasonal fluctuation because the area is used as yearlong range.

Endangered and/or Threatened Species. The only endangered and/or threatened mammal which may occur in the region is the black-footed ferret. Prairie dog towns are considered primary ferret habitat. No prairie dog towns exist on the Buckskin site, and the Wyoming

Game and Fish Department is satisfied that ferrets are not present (personal communication, Harry Harju 1978).

Amphibians and Reptiles

The two amphibians observed on the proposed mine site were the leopard frog and chorus frog. Leopard frog density is estimated at 1 per 10 feet of stream, and chorus frog density at 1 per 20 feet of stream.

A plains garter snake was the only reptile observed on the site.

Endangered and/or Threatened Species. No known endangered or threatened amphibian or reptile species are known to occur in the region or, therefore, on the project area.

CULTURAL RESOURCES

No sites in the Buckskin permit area are currently listed on the Wyoming Historic Preservation Plan or on the National Register of Historic Places.

Prehistoric

The entire Buckskin permit area was surveyed by the University of Wyoming (Zeimens and Walker 1977 and Zeimens et al. 1978). Two sites (48 CA 16 and 48 CA 17) are within the area which would be mined; they contained stone flakes, projectile points, and bone fragments. Neither site is considered to be of National Register quality (Zeimens et al. 1978).

Two prehistoric sites lie outside the area to be mined. One (48 CA 89) is an extensive group of stone circles with associated Late Prehistoric Period (1700 to 300 years before the present) artifacts. The portion of the site lying within the proposed rail access line to the mine was tested and recorded. The other site (48 CA 130) is an arroyo trap bison kill which also lies partially within the proposed rail right-of-way. It too was extensively tested in areas where it was likely to be affected. Eligibility for protection under the historic preservation laws for 48 CA 89 and 48 CA 130 cannot be determined until further testing is conducted on both sites (Zeimens et al. 1978). Such testing is not contemplated unless the operator finds additional disturbance necessary.

There is a possibility that buried archeological deposits exist along Rawhide Creek. Should such sites of potential National Register significance be indicated during overburden removal, appropriate mitigation would be conducted in consultation with the State Historic Preservation Officer and the Advisory Council as required in Section 106 of the Historic Preservation Act.

Historical

Recorded history began for the Buckskin Mine site in 1883 when section corners were set. The first application for a homestead was filed in 1902 and a second in 1903. The remaining acreage transferred to private ownership after 1916 and before 1925. The intensive cultural resource inventories conducted in the permit area did not reveal any physical evidence of these activities.

VISUAL RESOURCES

The characteristic landscape of the proposed Buckskin Mine site is open country with low rolling hills, scattered buttes, and occasional creek bottoms. There is little water or variation in vegetation, and there are no unique visual factors. Man-made intrusions into this setting are ranch buildings and equipment, roads, utility lines, and nearby coal mines. The western edge of the permit area and some of the high spots can be seen by people traveling south on U.S. Highway 14/16 for approximately 1½ miles at a distance of 1 mile.

A visual resource inventory was conducted using the Bureau of Land Management's visual resource inventory and evaluation procedures (see Regional Environmental Statement, Appendix B). The area falls into scenery quality Class C, because it lacks variety in landform, color variation, and color contrast. The permit area is in the foreground-middleground view zone, and has been identified as having medium visual sensitivity. Based upon the visual evaluation, the entire permit area has been assigned a Class IV visual resource management designation. This means that if the land involved were public, the Bureau of Land Management would allow permanent changes which alter the original visual character, but which reflect only what could be natural occurrences.

RECREATION RESOURCES

Recreation participation is limited on the proposed Buckskin Mine site because the land surface is privately owned. Hunting for antelope, mule deer, small game, and upland game birds is probably the only recreation opportunity. At the present time, the owner (Shell Oil) leases its property for grazing, and permission to hunt on the land is at the discretion of the lessee.

AGRICULTURE

Livestock Grazing

The land within the Buckskin Mine permit area is currently used for livestock grazing on an intermittent basis.

At the present time cattle ranching operations are being conducted by two operators. Cattle graze the main mining area (lease and 1,000-foot perimeter) during spring and summer for a yearly use of 243 animal unit months (AUMs). All permit areas (main mining area,

railroad, and access road) have an annual capacity of 320 AUMs.

Livestock water is provided by Rawhide Creek as well as a few ponds located on Spring Draw. Both quality and quantity of water appear adequate for present livestock use. Most of the riparian zone along Rawhide Creek in the southeast corner of Section 32 is grazed each year and also harvested for hay each summer.

Farming

Small scattered portions of the main mining area are being utilized on an intermittent basis for the production of hay and grain. Approximately 32 acres are utilized for the production of barley; they provide a yield of 25 to 40 bushels per acre. Two acres of wheat yield 25 to 30 bushels per acre. Hay production amounts to 1,000 to 2,000 pounds per acre on 87 acres, depending on climatic conditions. See Figure BU2-8 for the location of these scattered tracts.

Meadows and the acreages planted to introduced grasses are used for livestock grazing every year and are harvested for hay in years when precipitation is sufficient. No irrigation techniques are used on the area. Moisture is received from precipitation, flooding, and natural subirrigation.

Agricultural land must meet certain criteria (established by the Surface Mining Control and Reclamation Act (SMCRA)) to be classified as prime farmland. Because the Buckskin Mine site has no developed irrigation or dependable water supply system, and because annual precipitation is 14 inches or less, these criteria are not met. Therefore, prime farmland, as defined by SMCRA, does not exist on the site.

MINERAL RESOURCES

The coal bed to be mined at Buckskin is the Anderson-Canyon (Wyodak) at the top of the Fort Union Formation. It ranges in thickness from 0 to 125 feet, and averages about 107 feet. This thickness includes 2 to 5 feet of shale parting just above the middle of the seam.

The coal reserve at Buckskin is estimated by the applicant to be 84 million tons, of which 80 million tons is recoverable by present mining methods. (Four million tons of coal would be lost because current mining technology does not permit its economic separation from overburden and partings.) The coal is subbituminous in rank and has a heat rating of 8,183 BTUs per pound. On an undiluted, as received basis, it contains .51% sulphur, 29.8% moisture, and 6.11% ash.

There is no other ongoing or potential mineral development on the Buckskin site.

TRANSPORTATION NETWORKS

Railroads

The Burlington Northern (BN) is the rail system which serves Campbell County. The railroad line that passes through Gillette begins in Huntley, Montana, at a connection to the BN east-west Spokane, Washington to Fargo, North Dakota main line (see Figure BU2-9). From this point, the route follows a generally southeasterly alignment passing through Sheridan and Gillette, the southwest corner of South Dakota, and most of Nebraska before reaching Lincoln, Nebraska. The main railroad system is discussed in detail in the Regional Environmental Statement, Chapter 2.

Near Donkey Creek, a branch line leaves the main line in a northerly direction (see Figure BU2-9). This line has been established as far as the Carter Oil Company's Rawhide Mine. The Buckskin Mine would be served by a 6-mile spur line to be extended northwest from the end of the line serving the Rawhide Mine.

Highways

The major highway serving the immediate area of Buckskin Mine site is U.S. Highway 14/16, which runs north and south to the west of the lease. State Highway 59 runs north out of Gillette and passes east of the lease (Figure BU2-10). Several unimproved dirt roads which provide access for local traffic presently exist on or near the lease area.

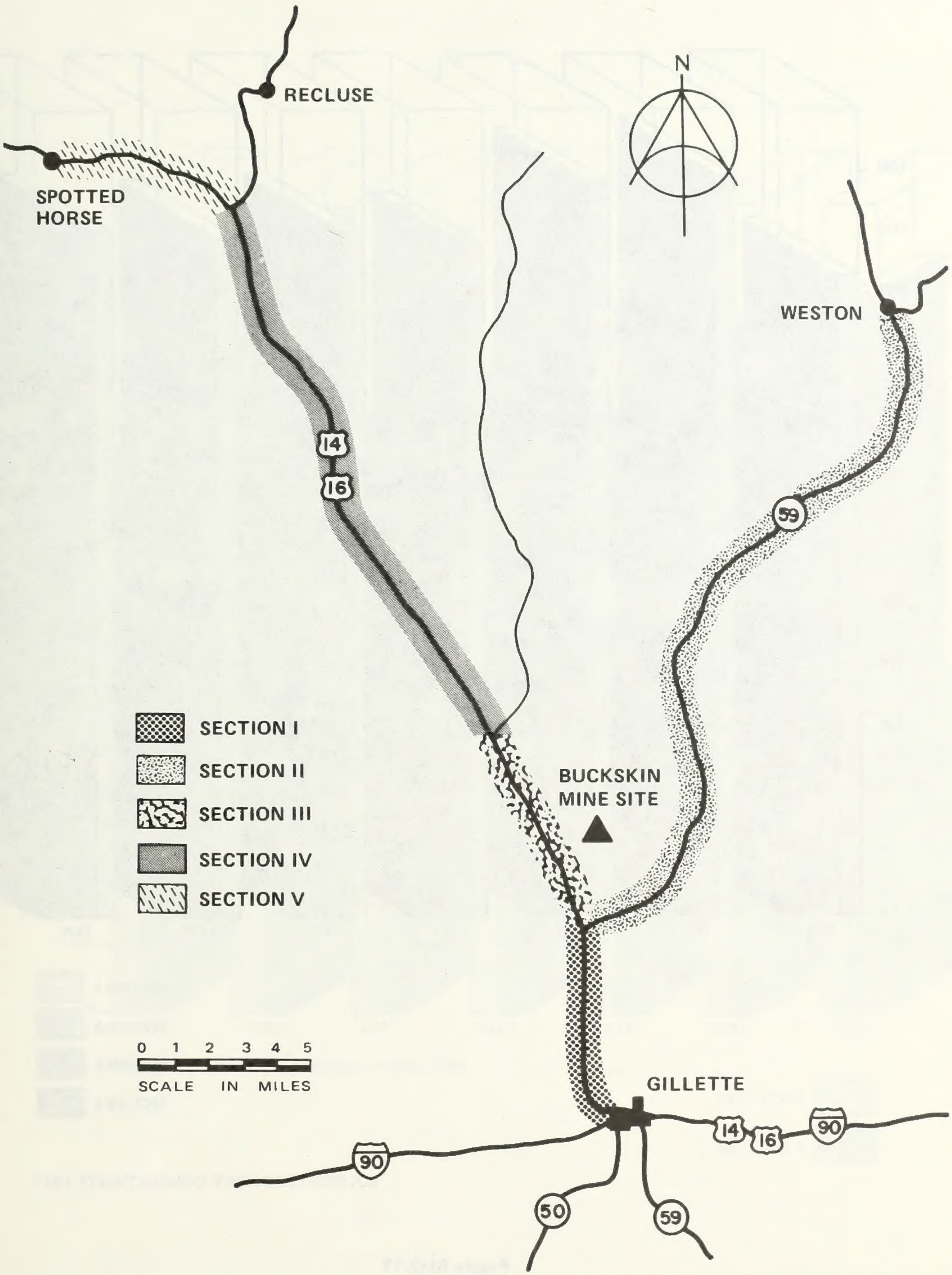
Traffic flow in 1958 on four sections of U.S. Highway 14/16 near the mine site is compared to traffic flow in years 1970 through 1975 on Figure BU2-11. Traffic flow for these years on two portions of State Highway 59 is given on Figure BU2-12. In 1958, before Interstate 90 was completed, virtually all traffic past the proposed Buckskin Mine site was through traffic. More recent traffic figures (1970 through 1975) illustrate that vehicular traffic has shifted to local traffic. As shown on Figure BU2-11 and Figure BU2-12, traffic levels have remained nearly the same or increased near Gillette and the lease area, whereas traffic levels have decreased on sections of U.S. Highway 14/16 and State Highway 59 farther north of Gillette. The increase near Gillette is likely due to the expansion of the coal and oil industries which has occurred in recent years.

In Gillette itself, 97% of the residents feel there is a definite need for improved city streets (City of Gillette/Campbell County Department of Planning and Development 1977 Citizens' Policy Survey).

Other

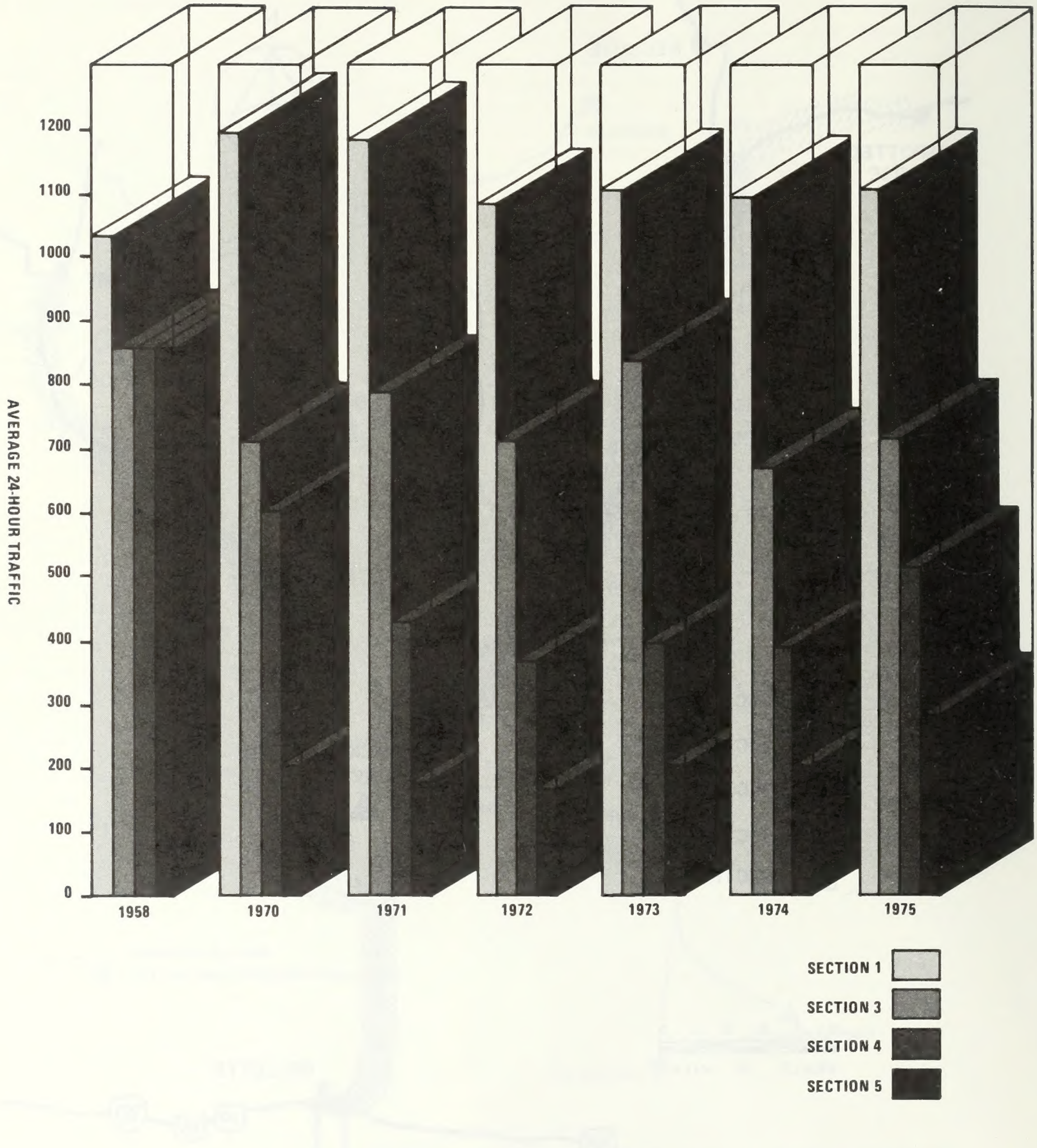
The Gillette-Campbell County Airport provides chartered and air taxi service. Almost 80% of Campbell County residents responding to the 1977 Citizens' Policy Survey agreed that the airport needs improved facilities. Total air operations at the Gillette-Campbell County Airport for 1976 were 53,578 (personal communication, Sam Stafford 1977).

Figure BU2-9
BURLINGTON NORTHERN RAILROAD SYSTEM POWDER RIVER BASIN



SOURCE: ECOLOGY CONSULTANTS 1977

Figure BU2-10
MAJOR HIGHWAYS IN THE VICINITY OF THE PROPOSED BUCKSKIN MINE



SOURCE: ECOLOGY CONSULTANTS 1977

Figure BU2-11

TRAFFIC FLOW ON U.S. HIGHWAYS 14/16 IN VICINITY OF BUCKSKIN MINE SITE

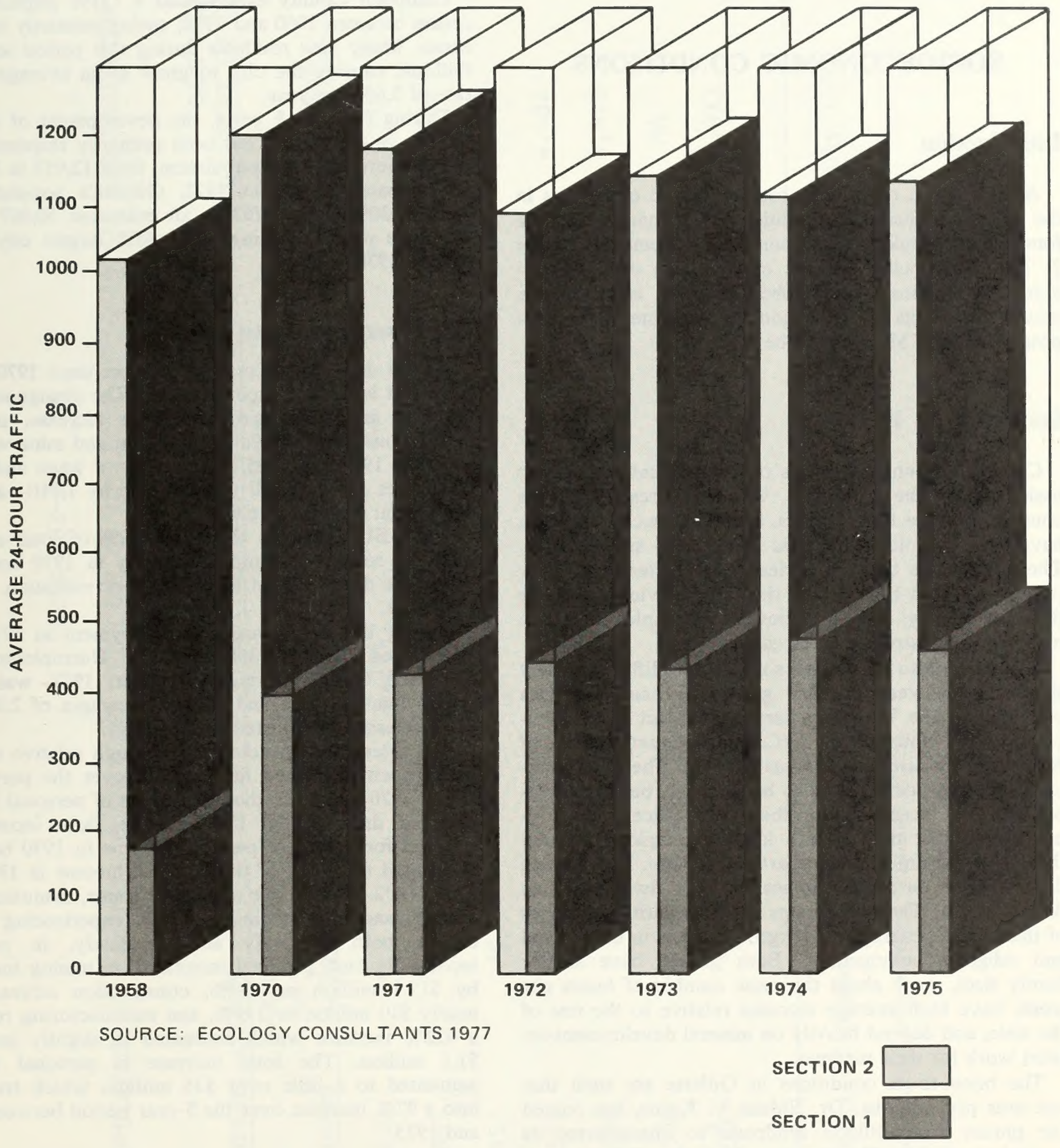


Figure BU2-12

TRAFFIC FLOW ON STATE HIGHWAY 59 IN VICINITY OF BUCKSKIN MINE SITE

Bus service is provided to Gillette from Casper, Wyoming and Billings, Montana by Continental Trailways. Telephone service is supplied for the Gillette area by Mountain Bell.

SOCIOECONOMIC CONDITIONS

Introduction

A description of existing socioeconomic conditions in the eight northeastern counties of Wyoming can be found in the Regional Environmental Statement, Chapter 2. This site-specific analysis concentrates on socioeconomic conditions in Campbell County and Gillette, where the effects of population increase due to the proposed Buckskin Mine would be felt.

Sociocultural Profile

Campbell County residents can be separated into two basic groups: the old-timers, who have resided in the county for more than 5 years, and the newcomers, who have not. The old-timers tend to be rural and agrarian. The newcomers tend to be less rural in terms of their pasts; they tend to settle in the Gillette vicinity rather than the county; they are most often employed in the mining and construction sectors.

It is possible to distinguish some of the differences and similarities between the two groups by analyzing data collected by the Wyoming Services Project of the University of Wyoming in 1976 *(Campbell County Parks and Recrea*tion Department *Citizens' Survey)*. The study indicates that newcomers tend to be younger, better educated, less rural (based only on their latest place of employment), and that they have a lower unemployment rate than their old-timer counterparts in Gillette. Newcomers depend more on mobile homes for their dwellings than do old-timers. The two groups have similarities in terms of their basic geographic backgrounds, and in their racial and religious homogeneity. Both groups have similar family sizes, work about the same number of hours per week, have high average incomes relative to the rest of the state, and depend heavily on mineral development-related work for their incomes.

The boom-town conditions in Gillette are such that one area psychologist, Dr. Eldean V. Kohrs, has coined the phrase "the Gillette syndrome"to characterize its conditions (1974). He has described the Gillette syndrome as a "social system of higher rewards and greater pains"that accompanies a boom-town growth situation. He feels it "... includes the three A's— alcohol, accidents, and absenteeism, as well as the three D's--divorce, delinquency, and depression"

Economic Profile

Local Demography

Table BU2-2 shows population figures from 1950 to the present.

Campbell County experienced a 121% population increase between 1960 and 1970, owing primarily to an oil boom. Many new residents during this period settled in Gillette, causing the city to grow at an average annual rate of 5.6% per year.

During the past 8 years, the development of coal resources in the county has been primarily responsible for a 23% increase in the population, from 12,957 in 1970, to an estimated 16,000 in 1978. Gillette's population increased 30% from 7,763 to an estimated 10,067 during the same period, making it the fifth largest city in the state in 1978.

Employment and Income

Recent data show a marked increase since 1970 in employment levels and income values. The change is due to inflation and the rapid population increase, most of which consists of skilled construction and mine workers. Between 1970 and 1975, the number of wage and salary employees in Campbell County rose by 1,710—an average annual increase of 6.4%.

Table BU2-3 shows the distribution of total employment by sector in Campbell County in 1970 and 1975. The table demonstrates the change, or evolution, in employment.

During the last 5 years, unemployment in Wyoming has varied between 3% and 5%. Unemployment in Campbell County during September, 1977, was 2.2%, lower than the state and national averages of 2.8% and 6.9% (seasonally adjusted) respectively.

It is interesting to note that although relative sectoral employment remained fairly stable over the period between 1970 and 1975, the distribution of personal income changed dramatically. For example, farm income accounted for 13.9% of personal income in 1970 but only accounted for 0.6% of the personal income in 1975 (see Table BU2-4). Over the same time frame, manufacturing, mining, and construction were all experiencing an increase, both relatively and absolutely, in personal income. In fact, personal income from mining increased by $15.1 million or 139%, construction increased by nearly $10 million or 199%, and manufacturing revealed a 622% increase which amounted to slightly less than $1.1 million. The total increase in personal income amounted to a little over $36 million, which translates into a 92% increase over the 5-year period between 1970 and 1975.

Cost of Living

The boom-town atmosphere created in Campbell County by the impact of current and anticipated coal mining has directly affected local residents. Gillette ranked as the most expensive place in Wyoming to live in the third quarter of 1977 for the seventh consecutive quarter, according to the Wyoming Department of

TABLE BU2-2

POPULATION OF CAMPBELL COUNTY AND THE CITY OF GILLETTE (1950-1976), AND PROJECTED POPULATION OF CAMPBELL COUNTY (1977-1990)

Year	CAMPBELL COUNTY Population	CAMPBELL COUNTY Annual rate of change in percent*	CITY OF GILLETTE Population	CITY OF GILLETTE Annual rate of change in percent*	CAMPBELL COUNTY EXCLUSIVE OF CITY OF GILLETTE Population	CAMPBELL COUNTY EXCLUSIVE OF CITY OF GILLETTE Annual rate of change in percent*
1950	4,839	---	2,191	---	2,648	---
1960	5,861	+2	3,580	+5	2,281	-1
1970	12,957	+8	7,763	+8	5,194	+9
1973	12,283	-2	7,801	**	4,482	-5
1975	13,090	+3	8,215	+3	4,875	+4
1976	14,500	+11	NA	---	NA	---
1978	16,000	+5	10,067	---	5,933	---

Source: U.S. Department of Commerce, Bureau of the Census, November 1970, April 1977, July 1977.

* Average rate of change compounded annually.
** Less than 1%.
NA = not available

TABLE BU2-3

WAGE AND SALARY EMPLOYMENT FOR CAMPBELL COUNTY
1970-1975

	1970	Percent of Total	1975	Percent of Total
Agriculture	157	(3.3)	188	(2.9)
Minerals	1,109	(23.6)	1,402	(21.9)
Construction	473	(10.1)	1,031	(16.1)
Manufacturing	27	(0.6)	84	(1.3)
Business and Consumer Services	2,157	(46.0)	2,733	(42.7)
Government and Education	767	(16.3)	962	(15.0)
Military	5	(0.1)	4	(0.1)
Total Wage and Salary Employment	4,694		6,404	

Source: U.S. Department of Commerce, Bureau of Economic Analysis (BEA) 1977.

Note: Table includes full- and part-time workers. BEA data on which this table is based deleted sector employment data where necessary to preserve confidentiality. In preparing this table, estimates were made of deleted items.

TABLE BU2-4

EARNINGS BY SECTOR FOR CAMPBELL COUNTY 1970-1975
(THOUSANDS OF CURRENT DOLLARS AND AS A PERCENT OF TOTAL EARNINGS)

	1970	Percent	1975	Percent
Farm	5,482	(13.9)	462	(0.6)
Manufacturing	172	(0.4)	1,242	(1.6)
Mining	10,909	(27.6)	26,057	(34.4)
Construction	4,985	(12.6)	14,883	(19.6)
Business and Consumer Services	15,594	(39.4)	29,404	(38.8)
Government and Education	2,160	(5.5)	3,430	(4.5)
Military	254	(0.6)	375	(0.5)
Total Income	39,556		75,853	

Source: U.S. Department of Commerce, Bureau of Economic Analysis 1977.

Note: Where the source contained deleted items, figures were estimated.

Labor and Statistics (November 9, 1977). The Wyoming cost of living index for Gillette was 107.61 (100 is the average cost in Wyoming). Housing is the expense that affects local residents the most. The cost index for the third quarter was 123.43, by far the highest above average in the six categories used to compute the cost of living index. The second highest expense was medical care with a cost index of 110.72.

The Public Sector

Introduction

Boom-town conditions such as exist in Gillette affect local services and finances. Annual population growth rates in excess of 10% strain the capacity of local facilities and services supplied by both the public and private sectors of the local economy. Although both sectors often face critical constraints on capital, labor, and time, impacts are apt to be acute in the public sector, because local government is subject to more stringent procedural and financial constraints and is highly visible to local residents.

Existing development of energy resources in Campbell County has not only strained local facilities and services, such as streets, water supply, sewers, and police and fire protection; development has also laid stress on local government itself and its planning function.

Land Use Patterns

The urban sprawl developing around Gillette is a symptom of rapid and often poorly controlled growth. The total acreage of the city in 1977 tripled from the 1965 amount (Table BU2-5). Residential acreage alone increased 33% during 1977. Land demand forecasts made for the Gillette urban area through 1990 estimate that 1,120 to 1,820 acres of private land will be developed (Table BU2-6). During the period 1972 through 1976, total building permit valuations issued by the City of Gillette/Campbell County Building Department jumped tenfold.

The Gillette urban area contains many areas of mixed land use. This pattern is most obvious in the original part of Gillette where the central business district is expanding into areas that have been primarily residential. The development along State Highway 59 has randomly mixed areas of residential, commercial, recreational, and industrial land use. This pattern of development also tends to occur outside the city limits.

Patchwork or "leapfrog"development results in enclaves of undeveloped land left within the urban area as development spreads outward from the city. Land speculation and the higher costs of development in the city have accelerated this tendency. Numerous mobile home subdivisions have recently developed in Campbell County outside of the Gillette urban area. Leapfrog development and the mobile home subdivisions complicate services such as mass transit, and police and fire protection.

The 1977 Citizens' Policy Survey (City of Gillette/Campbell County Department of Planning and Development) reflects local concerns about zoning and building codes and their enforcement. Of those surveyed, 75% either "agreed"or "strongly agreed"with the statement, "Zoning ordinances should be strictly and consistently enforced" Similarly, 79% felt that, "Zoning can protect property values and properly guide community development if enforced" Concerning building codes, 71% "agreed"or "strongly agreed"with the statement; "Uniform building codes should be adopted and enforced in platted subdivisions in unincorporated areas of Campbell County" Thus, local citizens appear to be aware of the implications of the land use patterns and construction practices that are occurring, and they feel that zoning and building codes should be used to shape future growth. While Gillette has both zoning and building codes, Campbell County has no zoning requirements and has only a plumbing code. The adequacy of zoning and building code enforcement is unknown.

Planning

The Gillette Planning Commission was formed in 1963, and a city master plan was adopted in that year. In 1968, a joint City of Gillette/Campbell County Planning Department was formed. The city's master plan was updated in 1973. The planning department has developed a land use plan for the Gillette urban area—the 6 mile by 5 mile area defined by the Gillette zoning ordinance. Planning for the impact of new coal mining has had high priority in the city administration since January 1975.

The first draft of the comprehensive plan for Campbell County, as required in part by the 1975 Wyoming Land Use Planning Act, was completed by the City of Gillette/Campbell County Department of Planning and Development on June 30, 1977, and submitted to the State of Wyoming for review. After review, revision, and adoption by the county, the comprehensive plan is to be: (1) the official statement of policy regarding the future development of the county, (2) a summary of a broad range of available information, and (3) a long-range planning program.

The draft proposes an unusual form of growth control, within the context of energy-related development pressure, which is to accommodate rather than stimulate or limit future growth. Sections of the land use plan that would prohibit surface mining within 2 miles of the city limits of Gillette, prohibit the granting of any new coal leases within 3 miles of the Gillette urban area, and separate coal mining and residential development have been controversial. (However, 73% of those responding to the 1977 Citizens' Policy Survey felt that coal mining should be at least 3 miles from the Gillette city limits.) Until the city and county adopt some form of a comprehensive plan, local government will lack a publicly stated policy intended to cope with continued growth.

TABLE BU2-5

LAND USE - CITY OF GILLETTE

Land use Types	1965 Total Acres	1965 % of Developed Acres	1976 Total Acres	1976 % of Developed Acres	1977 Total Acres	1977 % of Developed Acres
Residential	176.8	33.6%	480	32%	642	33%
Commercial	41.9	8%	115	7%	13.1	7%
Industrial	75.6	14.4%	160	11%	160	10%
Utility			50	3%	50	3%
Public-Semipublic	86.7	17%	120	7%	120	7%
Recreational	5.4	1%	150	10%	150	9%
Sreets & Alleys	136.3	26%*	405	27%*	450.85	29%*
Developed Areas	525.7	100%	1,480	100%	1,705	100%
Undeveloped Areas	523.9		1,090		1,342	
Interstate Right-of-way	____		280		280	
Total Acres	1,049.6		2,850		3,327	

Source: City of Gillette/Campbell County Department of Planning and Development 1978.

* This figure includes major streets. Within single-family developments, 20% is a desirable figure.

TABLE BU2-6

LAND DEMAND FORECASTS FOR THE GILLETTE URBAN AREA 1976-1990

General Land Use Category	Low Range Forecast	High Range Forcast
Residential	1,120 acres	1,820 acres
Retail	29 acres	80 acres
Commercial Office, Institutional & Related	9 acres	17 acres
Industrial	48 acres	90 acres
Total	1,206 acres	2,007 acres

Source: City of Gillette/Campbell County Department of Planning and Development 1978.

There is as yet no publicly stated federal policy for future development of federally owned coal in Campbell County. Of those surveyed in the 1977 Citizens' Policy Survey, 57% felt that local citizens had no real opportunity to participate in the decisions made at the federal level regarding energy development, while 22% felt they did.

Local Government

In 1968, Gillette's annual budget was $812,000. The 1977-1978 budget is $7,348,000, more than nine times the size of the 1968 budget. The current city budget is 28% greater than the previous year's budget. A city administrator was hired during 1977 to help the mayor govern the city. The city government, in conjunction with the town of Moorcroft, Wyoming, recently obtained a $50,000 management program grant, funded by the Federal Energy Administration and the state government, to improve the city's administrative ability. Increased demand for county services caused the Campbell County government to increase its 1977-78 budget to $4,430,000, up 44% from the previous fiscal year.

Fire Protection

Fire protection is provided by the City of Gillette/Campbell County Fire Department under direction of a fire board and a county fire warden. The department consists of a full-time fire chief and 4 firemen, supplemented by approximately 19 active volunteer firemen. The city and county each fund the department through a one-half mill levy on personal property. The 1977-78 budget is $178,000. Of those responding the the 1977 Citizens' Policy Survey, 39% felt fire protection was adequate, while 32% felt that it needed improvement.

Police Protection

Police protection is provided in Gillette by a 26-person force. The sheriff's department provides protection for the entire county, including the city. The 1977-78 budget for the Gillette Police Department is $614,000; that of the sheriff's department is $404,000, up by 23% from the previous year's budget. Of those responding to the 1977 Citizens' Policy Survey, 70% of county residents residing outside of Gillette felt that county police protection needed improvement, and 79% of city residents felt that traffic control needed to be improved.

In 1973, the Gillette Police Department had 2.22 policemen per 1,000 city residents. The 1977 figure was 0.75 per 1,000, while the national average was 1.9 per 1,000, emphasizing the lag between rapid population growth and expanded city services. In addition, the turnover rate at the Gillette Police Department is very high, and is partially attributable to the cost of living in Gillette.

Water Supply

Gillette obtains its water supply from local wells tapping the Wasatch or Fort Union Formation. Surface water is not readily available in Campbell County, and it is not used as a domestic water source. Historically, the city's water supply has been inadequate for summer needs, and the water has been of poor quality, either being very hard, or soft with the smell of hydrogen sulfide. Of those residents of Gillette responding to the 1977 Citizens' Policy Survey, 80% felt that the water supply needed improvement, and 95% felt that the quality of the water needed improvement.

In order to reduce the impact of new subdivision approvals on the city's water supply system, Gillette began requiring that all new subdivisions provide well sites. In addition, in order to assure adequate financing to provide sufficient water in each new subdivision, the city increased tap fees from $250 plus costs to $950 plus costs.

During 1977, Gillette markedly improved its water supply system by (1) renovating its pretreatment water plant, (2) drilling two new soft water wells (costing $163,000) and renovating several abandoned water wells, and (3) tripling the city's water storage capacity for summer needs to 6 million gallons (costing $1.5 million). The city's water now undergoes lime softening, electrodialysis, and degasifying before it is supplied to city residents.

Waste Disposal

Gillette constructed a $4.19-million sewage treatment plant in 1974 that has a capacity of 1.4 million gallons of sewage per day. Funding was supplied by the Environmental Protection Agency (EPA) and distributed by the State of Wyoming. The Wyoming Department of Environmental Quality (DEQ) granted the city a discharge permit for the new plant in April 1974.

The plant is currently processing an average of 0.76 million gallons per day with peak loads approaching 1.4 million gallons per day. The city government has stated that the plant has been operating at capacity since 1975. During the summer of 1976, the city increased its sewer tap fee to $1,081 per residential tap in order to increase revenues.

Raw sewage, some of which presumably comes from outside of the city limits, can currently be disposed of at the city's sewage treatment plant, further impacting the plant's limited capacity. The city is considering drastically increasing the rates charged for disposal of the raw sewage in order to increase revenue and discourage use of the disposal service.

Of those residents of Gillette responding to the 1977 Citizens' Policy Survey, 63% felt that the city's sewage treatment needed improvement; however, 40% of the residents of mobile home parks and residential subdivisions in Campbell County felt that there was a critical need for improvement of sewage treatment facilities. Campbell County has experienced periodic health problems arising from the operation of mobile home parks,

and the county administration is apparently developing countywide regulations to govern sanitation practices.

Solid waste from Gillette is placed in an 80-acre sanitary landfill project that is located on the southwestern edge of the city. The site can be utilized for another 5 or 6 years. The city has been unable to secure a future landfill site that meets federal and state regulations.

Industrial oil is apparently being illegally dumped into the city's sewer system, adversely affecting the biological treatment system used at the sewage treatment plant. Neither the city nor the county currently provides facilities for disposal of industrial oil.

Medical Facilities

The Campbell County Memorial Hospital, with a capacity of approximately 30 beds and newly improved emergency room facilities, is located in Gillette. The Northeast Wyoming Regional Medical Center and the Medical Center of Campbell County are also located in Gillette. Medical service in Campbell County is provided by nine doctors; there are thus 1,778 patients for every practicing physician.

Of those Campbell County residents responding to the 1977 Citizens' Policy Survey, only 6% indicated that local medical service is adequate while 60% felt that there was a critical need for improved service. Until recently, local medical service was critically understaffed. Some overworked doctors left the county, and service was often difficult to obtain. Many dissatisfied residents apparently obtained medical service outside the county. The Campbell County Hospital Board successfully recruited five doctors during the fall and winter of 1977, reducing the doctor shortage. The goal of the hospital board is to eventually have one doctor per 1,000 residents.

The residents of Campbell County passed an $8.5 million bond issue June 23, 1976 for construction of a new county hospital. Construction of the 55-bed facility began during the fall of 1977, but completion of the facility will not occur for several years.

Although existing medical facilities and service have been impacted by rapid population growth, improvement of both the facilities and service did occur during 1977.

Education

Classroom space and number of teachers are currently adequate in Gillette.

The Private Sector

Introduction

Boom-town conditions also affect the private sector of the local economy. Services, such as motels, restaurants, and retail stores, are often overwhelmed by local population growth. Local lending institutions are often hard pressed to finance local private sector expansion. Uncertainty about future developments causes investors to be wary.

Housing

Normally, increases in economic activity and population growth are signs of opportunity to the housing industry. Increased housing demand is expected to stimulate increased housing production in roughly the quantity of units, the mix of unit types, and the price ranges demanded. However, in Gillette increased housing demand has come in difficult-to-predict waves to a geographically isolated community, which did not have a well-developed housing industry to begin with. The result has been a series of mutually reinforcing problems.

Single-Family Homes. A recent opinion poll in Campbell County found that 85% of all respondents desired to live in single-family homes (1977 City of Gillette/Campbell County Citizens' Policy Survey). There is evidence that as the mining work force in Campbell County shifts from construction workers to permanent workers, and as more construction workers view their stay in Gillette as long term, this preference for single-family homes can be expected to increase.

The local housing situation is not able to satisfy these preferences. Table BU2-7 describes the existing housing stock in the county. About 30% of the available dwellings are single-family units. The majority of these units are several years old, and located within the city of Gillette. Fifty-four percent of the housing stock is mobile homes, mostly recent additions located just outside the city limits. Table BU2-8 shows the changes in the housing stock since 1970. Only 30% of the new housing in Gillette is single family.

The overall cost of housing in Gillette is presently estimated to be 17% higher than in nearby Sheridan, 19% higher than in Wyoming communities in general, and 23% higher than the Denver metropolitan area, which serves as the regional financial center (Wyoming Department of Labor and Statistics 1977). This, however, may be understating the difference in price for new dwellings of common size and quality of construction. Developers who market similar houses in both Gillette and the Denver metropolitan area indicate that costs of production are 30% higher in Gillette than in Denver. New single-family units in Gillette, whether modular or conventionally constructed, are seldom priced at less than $46 per square foot. For most builders, the "bottom of the line"is a 1,100-square-foot home for roughly $51,000.

The reason for this price differential is found in the developer's costs. As a result of land speculation, finished lots may cost $7,500 to $14,000 before tap fees (25% to 40% higher than in the Denver area). Facing financial difficulties of its own, the City of Gillette is charging approximately $2,100 for water and sewer tap fees (considerably higher than in the Denver area). Plumbing subcontracts may cost $2,000, or more, per unit (50% to 100% higher than in the Denver area). Carpentry labor may cost $7.00 to $12.00 an hour (8% to 85% more than in the Denver area where the union wage is $6.50 an hour).

TABLE BU2-7

EXISTING HOUSING STOCK IN CAMPBELL COUNTY, JULY 1977

Type of Dwelling Unit	City of Gillette		Remainder of Campbell County		Totals	
	Number	Percent	Number	Percent	Number	Percent
Single-Family	1,623	42.3	515	15.9	2,138	30.1
Rural Dwellings	.0	0	396	12.2	396	5.5
Duplexes (no. of units)	181	4.7	8	0.2	189	2.6
Multi-Family (no. of units)	499	13.0	28	0.9	527	7.4
Mobile Homes (in parks)	1,154	30.0	1,805	55.6	2,959	41.8
Mobile Homes (outside parks)	378	9.8	494	15.2	872	12.3
Total	3,835		3,246		7,081	

Source: City of Gillette/Campbell County Department of Planning and Development 1978; U.S. Department of Commerce, Bureau of the Census 1972.

TABLE BU2-8

CHANGES IN THE HOUSING STOCK, 1970-1977

	Total Units 1970	Total Units 1977	Net Change 1970-1977	Percent of the Increase of New Housing Stock 1970-1977
Gillette				
Single-Family	1,139	1,623	484	30
Duplexes (no. of units)	165	181	16	Less than 1
Multi-Family (no. of units)	279	499	220	14
Mobile Homes	645	1,532	887	55
Total	2,228	3,835	1,607	
Campbell County (including Gillette)				
Single-Family	1,782	2,138	356	19
Duplexes (no. of units)	172	189	17	Less than 1
Multi-Family (no. of units)	318	527	209	11
Mobile Homes	1,644	2,959	1,315	69
Total	3,916	5,813	1,897	

Source: U.S. Department of Commerce 1972, City of Gillette/Campbell County Department of Planning and Development 1978, Denver Research Institute 1977.

Thus far, with single-family units comprising such a small portion of the available housing stock, it has been a sellers' market. Houses priced below $60,000 are usually sold before construction is completed.

Inflated housing production costs have placed the goal of a single-family dwelling beyond the reach of many newcomers. At prevailing conventional mortgage terms, a household would require almost $7,000 in cash and a $22,000 annual income in order to purchase a $55,000 home. (The most common terms are 9¼% to 9½% (including ¼% for private mortgage insurance) for 30 years, with a 10% down payment. In addition to the down payment, closing costs average $1,300. Most lending institutions require that principal and interest payments not exceed 25% of a household's gross monthly income, or that its total debt liabilities not exceed 30%. Using a 9½% interest rate and the 25% rule, for a $55,000 home; the annual income requirement would be $21,780.) By regional standards, wages in Campbell County are excellent. Mining wages average $19,700 per year; all other occupations combined average $14,400 per year (personal communication, Wolford, Employment Security Commission of Wyoming 1977). Nevertheless, most households are unable to afford a single-family house unless they have more than one full-time wage earner.

Mobile Homes. As Tables BU2-7 and BU2-8 indicate, mobile homes are the most prevalent and the fastest growing housing alternative in Campbell County. Sixty percent of the increase in housing since 1970 has been in mobile homes. Presently, 67% of the housing in the county outside Gillette is mobile homes.

Mobile homes, including campers, are the most common alternative for those who would have preferred single-family dwellings. While they are by no means inexpensive, mobile homes are priced at a level within the reach of most local households. The typical purchase requires $1,800 in down payment and an annual income of $7,200. Typical principal and interest payments are $150 per month. Many households presently living in mobile homes hope to use them as "starter homes,"to sell their mobile homes and use the equity to purchase single-family dwellings.

Thus far, mobile homes have worked well as starter homes. Rapid increases in housing demand and inflation in the cost of new mobile homes have resulted in high resale value for existing units. Units have tended to appreciate in value, which is contrary to the national pattern. However, planners are concerned that over the next decade, large numbers of mobile homes will deteriorate in physical condition, since their life span is much shorter than that of traditionally constructed dwelling units.

Conditions have changed since the initial phase of Gillette's housing boom when mobile home parks were an attractive investment. While banks and private mortgage companies have been successful in packaging and selling home mortgages to the secondary mortgage market, there is still an acute shortage of local commercial credit. As a consequence, local loans for all but the most favorable new business ventures, which presently excludes new mobile home parks, are difficult to obtain.

There is already a shortage of mobile home spaces in and around Gillette. Barring further housing development initiatives by the coal companies, it is likely to get worse. Anti-mobile home sentiment already exists among bankers and community leaders; consequently, their support of plans to increase the number of mobile home lots will probably be minimal.

Multi-Family Units. As Table BU2-8 indicates, less than 10% of the new dwelling units in the county have been duplexes or multi-family units. For the most part, these have been rental units. There is a great need for more rental units. The Gillette Chamber of Commerce has recently begun a rental referral service to assist newcomers in finding apartments. It has far more requests for referrals to rental units than it can fill.

As with mobile home parks, the main reasons for this shortage are the relatively high level of risk associated with new apartment developments and the shortage of local commercial credit. The risks to commercial lenders for apartments are seen as particularly high since initial capital investment is high and apartment vacancy rates are dependent on such a large number of variables. Actions by coal companies to improve housing conditions, such as subsidies of single-family units, could have the side effect of decreasing the demand for apartments.

Partially because of increased business activity and partially because of the shortage of long-term rental units, there is also a shortage of transient quarters. Many newcomers find themselves forced to live in motel rooms for long periods of time while searching for other housing alternatives. Unfortunately, motel space is also in extremely short supply.

FUTURE ENVIRONMENT

If the proposed mining does not take place, and if Shell Oil does not sell or use the land surface for a purpose other than coal mining, the project area would continue to exist in its present condition, subject to modification by natural processes, or the continuation of existing uses, including approved coal mines in the vicinity. The project area may be subject to increased casual use by hunters, off-road vehicle users, and collectors due to increased regional population; since the land is privately owned, such use would be restricted. Local transportation improvements would continue as planned without approval of the Buckskin Mine (see Regional Environmental Statement, Chapter 8, Low-Level Scenario, Transportation Networks). Socioeconomic impacts of the same type and virtually the same magnitude would occur in the region with or without the proposed mine. See Regional Environmental Statement, Chapter 4, Socioeconomic Conditions for a complete discussion of regional and local effects of mineral development.

CHAPTER 3

ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

INTRODUCTION

The analysis developed in this chapter is an assessment of impacts that would result from development of coal on the proposed Buckskin project. Impacts are quantified by time periods 1980, 1985, 1990, and end of mine life. Quantification may be stated as an increment for the time period or as a cumulative total at the end of each time period. The method of quantification that best describes the impact will be used.

Mining and reclamation plans for the proposed Buckskin Mine, as well as for mines currently operating or pending approval and already under study in separate environmental statements (ESs), were submitted prior to passage of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), PL 95-87. Therefore, the plans may not reflect all the requirements of the law. All plans must be modified by the respective companies to meet SMCRA requirements. In the case of Buckskin, prior to final approval of the authorizing agencies, the modified plan will be reevaluated to insure (1) that it satisfies the requirements of SMCRA and the resultant federal regulations, and (2) that the potential impacts of mining have been covered by environmental analysis. This procedure will allow timely consideration of Shell's application to mine (which is complete in other respects), while the requirements of SMCRA are still evolving.

Chapter 3 of the Regional ES, Planning and Environmental Controls, refers to provisions of SMCRA which are applicable to the coal mining in the region. These were considered in the following impact analysis to the extent possible. However, some of the impacts described may be precluded by eventual implementation of the new law.

ANALYSIS GUIDELINES

An analysis of impacts requires establishing guidelines for coal-related development. The following narrative and tables were developed to establish such guidelines for the proposed Buckskin project.

Guidelines

1. Impacts are analyzed for four time points (1980, 1985, 1990, and end of mine life).

2. Reclamation on an area is considered complete when disturbed lands have been backfilled, graded, contoured, revegetated, approved, and bond is released in accordance with an approved reclamation plan (Wyoming Land Quality Rules and Regulations 1975, and the Surface Mining Control and Reclamation Act of 1977).

3. Any impacts lasting after closure of the mine and release of bond will be considered long-term impacts.

4. Acreage and water requirements are assumed using guidelines set forth in Table BU3-1, unless the information is specified by the applicant.

The following tables are presented to provide an overview of total land disturbance that would occur by the development of the Buckskin project. Table BU3-2 portrays the areas of land disturbed and reclaimed during each designated time period by various activities related to the project. Table BU3-3 portrays the disturbance and reclamation of the same acreage as cumulative totals for each time period by activities.

CLIMATE

It is not expected that mining activities at the proposed Buckskin Mine site would affect precipitation. Possible changes in the radiation balance due to changes in the character of the soil would be undetectable. The alteration of the terrain may change onsite wind patterns, but this impact would be undetectable beyond a local level. The extent to which onsite updrafts increase or decrease in intensity would be difficult to determine; however, any changes would probably be insignificant.

AIR QUALITY

Emissions from the Proposed Mine

Nine major sources of fugitive dust would be associated with the proposed mine: haul road traffic, shovel/truck loading, blasting, truck dumping, drilling, topsoil removal, front-end loading, access road traffic, and wind erosion from exposed areas. Two point sources would be the coal crusher and the load-out facility. Table BU3-4 lists these emissions sources and the corresponding emission factors.

The annual emissions from the proposed site (Table BU3-5) were calculated using the emission factors listed in Table BU3-4. The operational parameters were ob-

TABLE BU3-1

Acreage Requirements

Facility	Approximate Acres Required
Power line	6 per mile
Railroad spur (100-foot right-of-way)	12 per mile
Roads (100-foot right-of-way)	12 per mile
Population increase	100 per 1,000 people
Coal mining (includes mine facilities, ancillary facilities)	140 per mine

Water Requirements

Facility	Acre-Feet
Per 1,000 population increase (urban)	190 per year*
Mine operations	20 per million tons coal**

* Based on present water use by the city of Gillette.

** ES team estimate

TABLE BU3-2

Acreage Disturbed by Activity and Acreage
Reclaimed Over Periods of Time
(Noncumulative)

ACTIVITY	TIME PERIODS 1980	1985	1990	1990+*	TOTAL
Mining	21	236	120	281	658
Mine facilities	140	0	0	0	140
Access road**	72	0	0	0	72
Railroad Spur***	72	0	0	0	72
Stockpiles****	129	0	0	0	129
Subtotal	434	236	120	281	1,071
Population*****	45	0	0	0	45
Total	479	236	120	281	1,116
Acres Reclaimed	0	0	14	1,057	1,071

* To end of mine life which is estimated to be the year 2000.
** 200-foot right-of-way with 100-foot usable width.
*** 100-foot right-of-way.
**** Topsoil stockpiles in continual use, years -2 to 21, no breakdown attempted. Overburden stockpiles are within the mining area.
***** Assumed using Table BU3-1.

TABLE BU3-3

Acreage Disturbed by Activity and Acreage
Reclaimed Over Periods of Time
(Cumulative)

ACTIVITY	TIME PERIODS 1980	1985	1990	1990+*
Mining	21	257	377	658
Mine facilities	140	140	140	140
Access road**	72	72	72	72
Railroad spur***	72	72	72	72
Stockpiles****	129	129	129	129
Subtotal	434	670	790	1,071
Population*****	45	45	45	45
Total	479	715	835	1,116
Acres Reclaimed	0	0	14	1,071

* To end of mine life which is estimated to the year 2000.
** 200-foot right-of-way, with 100-foot usable width.
*** 100-foot right-of-way.
**** Topsoil stockpiles in continual use, years -2 to 21, no breakdown attempted. Overburden stockpiles are within the mining area.
***** Assumed using Table BU3-1.

TABLE BU3-4

FUGITIVE AND POINT SOURCES IDENTIFIED AT THE PROPOSED MINE WITH CORRESPONDING EMISSION FACTORS

Emission Source	Emission Factor
FUGITIVE:	
1. Haul Roads	4.3 lb/vehicle mile traveled
2. Shovel/Truck Loading	
a. Coal	0.0035 lb/ton loaded
b. Overburden	0.037 lb/ton loaded
3. Blasting	17 tons/1,000,000 tons of coal mined
4. Truck Dumping	
a. Coal	0.007 lb/ton dumped
b. Overburden	0.002 lb/ton dumped
5. Drilling	
a. Coal	0.22 lb/hole drilled
b. Overburden	1.5 lb/hole drilled
6. Topsoil Removal	
a. Scraping	0.35 lb/cubic yard scraped
b. Dumping	0.03 lb/cubic yard dumped
7. Front-end Loading	0.12 lb/ton of coal loaded
8. Access Road Traffic	5.16 lb/vehicle mine traveled*
9. Exposed Areas (wind erosion)	0.4 ton/acre/year**
POINT SOURCES:	
1. Coal Crusher	0.005 lb/ton crushed
2. Load-Out Facility	0.0002 lb/ton loaded

Source: PEDCo Environmental, Inc. 1978a, except as noted.
* Calculated from formula in U.S. Environmental Protection Agency 1976a.
** Calculated from formula by Midwest Research Institute 1974.

TABLE BU3-5

ANNUAL EMISSIONS FROM THE PROPOSED BUCKSKIN MINE SITE

Emission Source	Tons per Year 1980	1985	1990	1999*
FUGITIVE DUST				
1. Haul Roads (with watering)	262	575	664	333
2. Shovel/Truck Loading	28	134	147	122
3. Blasting	68	68	68	68
4. Truck Dumping	15	21	22	20
5. Drilling	2	4	4	4
6. Topsoil Removal	55	47	39	107
7. Front-End Loading	24	24	24	24
8. Access Roads	206	206	206	206
9. Exposed Areas (wind erosion)	101	95	100	94
10. Load-Out Facility	<1	<1	<1	<1
11. Crusher	1	1	1	1
TOTAL FUGITIVE DUST	763	1,176	1,276	980
GASEOUS POLLUTANTS				
1. Vehicles				
Carbon Monoxide	6.2	9.0	6.2	3.6
Hydrocarbons	0.7	0.8	0.7	0.4
Nitrogen Oxides	1.6	3.4	1.7	1.0
Sulfur Oxides	0.3	0.8	0.9	0.5

* Last active year of mining.

tained from the mining and reclamation plan and personal communications with mining representatives. Emission inventories were performed for the mining years of 1980, 1985, 1990, and 1999, which would be the last active year of mining. These inventories are the best approximations of the complex interaction of variables.

The only potential air pollution source identified at the Buckskin Mine site other than fugitive dust sources would be exhaust emissions from diesel-powered haul trucks and from employee motor vehicles on mine access roads. Emission factors for vehicular travel were obtained from the Environmental Protection Agency's (EPA's) most recent compilation of mobile source emission factors, and they reflect current legislation relative to future emission standards in high altitude areas (EPA 1978).

Estimated emissions of carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x) and sulfur oxides (SO_x) are shown in Table BU3-5. These emissions are from both employee travel on the mine site and haul trucks.

Emission rates shown in the table reflect the measures proposed by Shell Oil Company in its mining and reclamation plan.

Impact on Air Quality

The impact of the above annual emissions on the nearby ambient total suspended particulate (TSP) concentrations was determined by use of the Modified Climatological Dispersion Model-Version 3 (MCDM-V3) (PEDCo Environmental, Inc. 1976). The model performs both annual averaging and worst-case 24-hour periods. Source data input consists of the following: source locations; source emission rates; emission heights; locations where ground-level pollutant estimates are desired; frequency of occurrence of each of sixteen wind directions, six wind speeds, and six stability classes; and particulate fallout functions. Climatological data were collected at the Moorcroft weather station, because the weather station at Gillette had insufficient data.

Figures BU3-1 through BU3-4 show the annual predicted and resulting ambient TSP concentrations for the years 1980, 1985, 1990, and 1999, as determined by the model. Figures BU3-5 through BU3-8 show the worst-case 24-hour predicted and resulting ambient TSP concentrations for the same years. Concentrations in both situations are shown to decrease rapidly with distance.

Figures BU3-1 through BU3-4 show there would be no violations of the annual Wyoming state standard of 60 micrograms per cubic meter ($\mu g/m^3$) beyond the boundary of the proposed mine site for all four study years. The exception to this would be the air quality in close proximity to the access road as a result of employees arriving at and leaving the mine each work day. However, 0.3 miles from the access road, no annual concentrations would be northwest and southeast of the mine site as a result of predominant wind directions, but even in these areas, resulting ambient TSP concentrations would decrease rapidly such that impact from the proposed facility would be essentially negligible (10 $\mu g/m^3$) 2.2 miles from the mine property boundary.

Figures BU3-5 through BU3-8 indicate that no violations of the worst-case 24-hour Wyoming state standard of 150 $\mu g/m^3$ would occur beyond the mine boundary. As was the case with annual concentration, the exception would be air quality in close proximity to the access road. However, no violations would occur beyond 0.3 miles from the access road.

Note that the above TSP violations include the fugitive dust generated by the mine and vehicular traffic. Because the new prevention of significant deterioration of air quality regulations (43 CFR 118) exclude most of these emissions, no violations would occur. In fact, air quality at the mine would be well within the applicable national ambient air quality standards.

Gaseous Pollutants

Vehicle emissions would be the only source of gaseous air pollutants from the proposed facility. Predicted concentrations of these pollutants were not modeled due to the lack of detailed data on vehicle use and applicable background data. However, recent studies (U.S. Department of the Interior 1976) on the impact of vehicle emissions associated with western coal mines estimate the probable range of impact to be insignificant. Assuming similar vehicle activity for the proposed mine, ambient concentrations of gaseous pollutants would be minimal and insignificant compared to their respective standards.

Visibility

The addition of particulates to the atmosphere would reduce visibility in the area. However, considering the extremely low predicted concentrations from the proposed facility, no perceptible visibility changes would be anticipated. Visibility would be expected to continue to exceed 60 miles at times and average between 26 to 47 miles, depending on climatological conditions such as fog, rain, or snow.

TOPOGRAPHY

During mining, the topography at the proposed mine site would be characterized by open pits, steep slopes, spoil piles, and haul roads.

When mining is completed, backfilling and grading efforts would restore the topography to a large, smooth-sloped, open-ended depression with new drainage patterns as shown on Figure BU3-9. When reclamation is completed in 2001, Shell estimates that the topography would be an average of 75 feet lower than it is now. Some revision of design may be necessary to meet Office of Surface Mining requirements for keeping reclaimed topography in concert with contiguous operations.

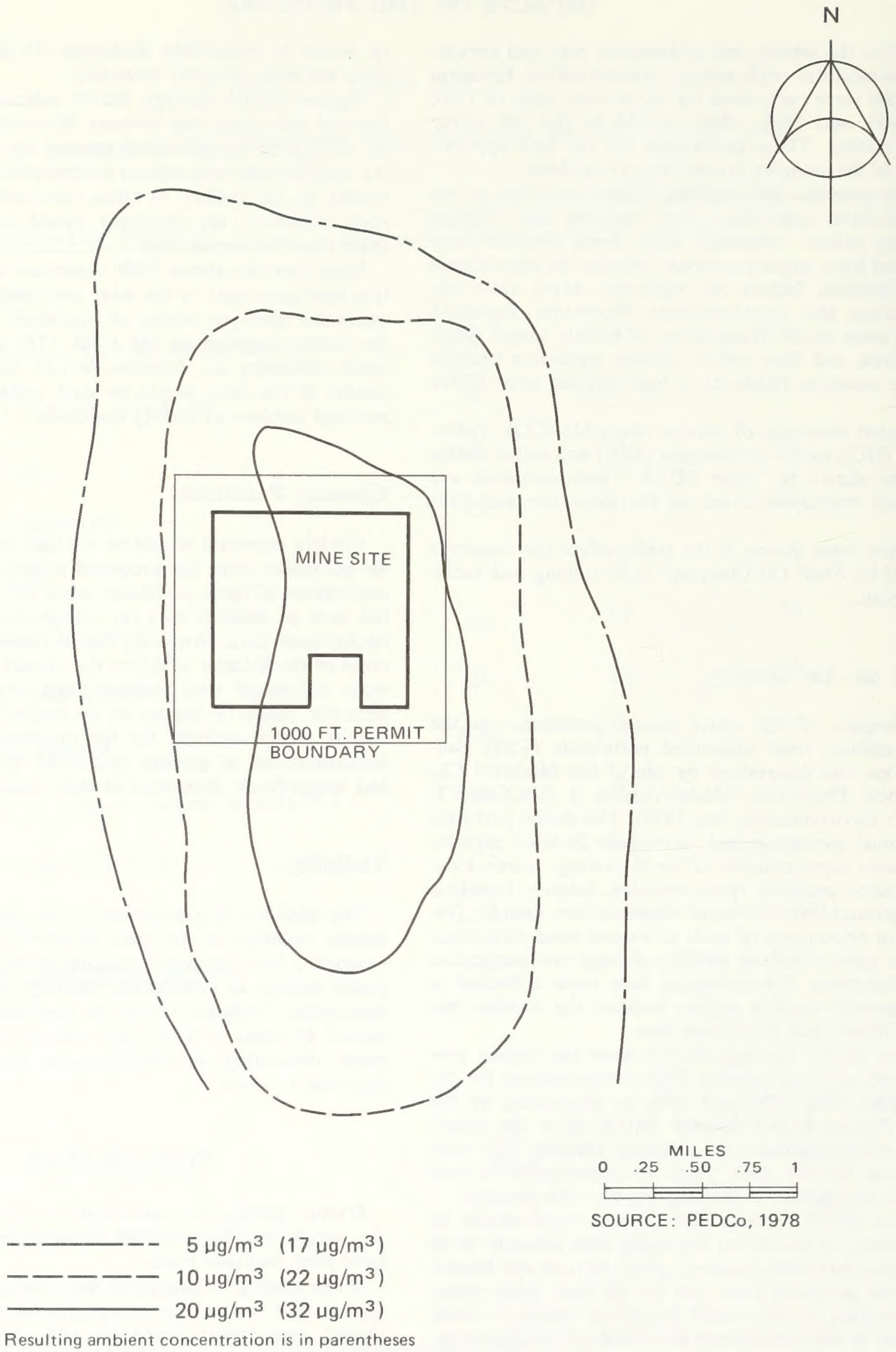


Figure BU3-1

ISOPLETH DIAGRAM SHOWING ANNUAL PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1980

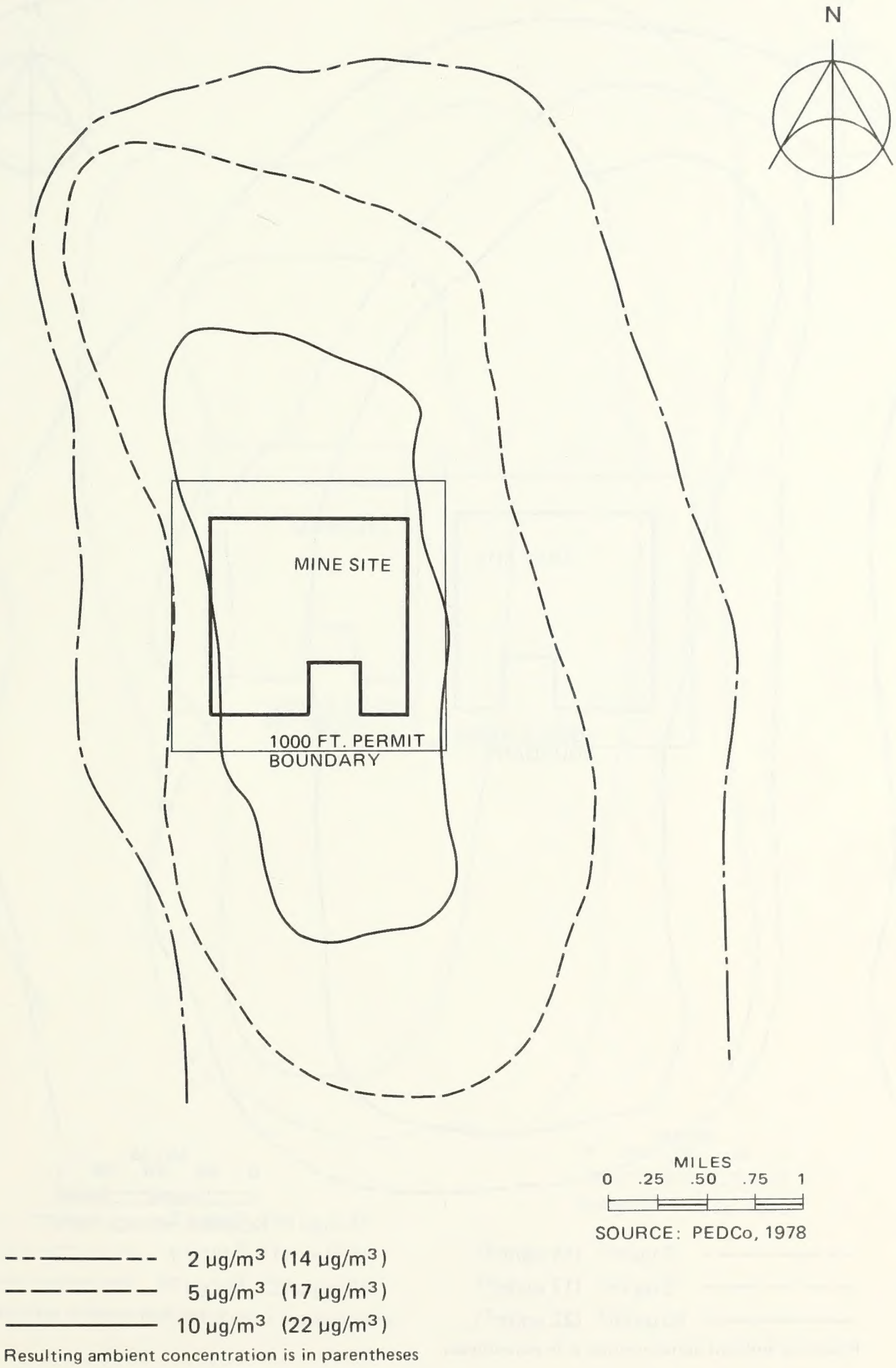


Figure BU3-2

ISOPLETH DIAGRAM SHOWING ANNUAL PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1985

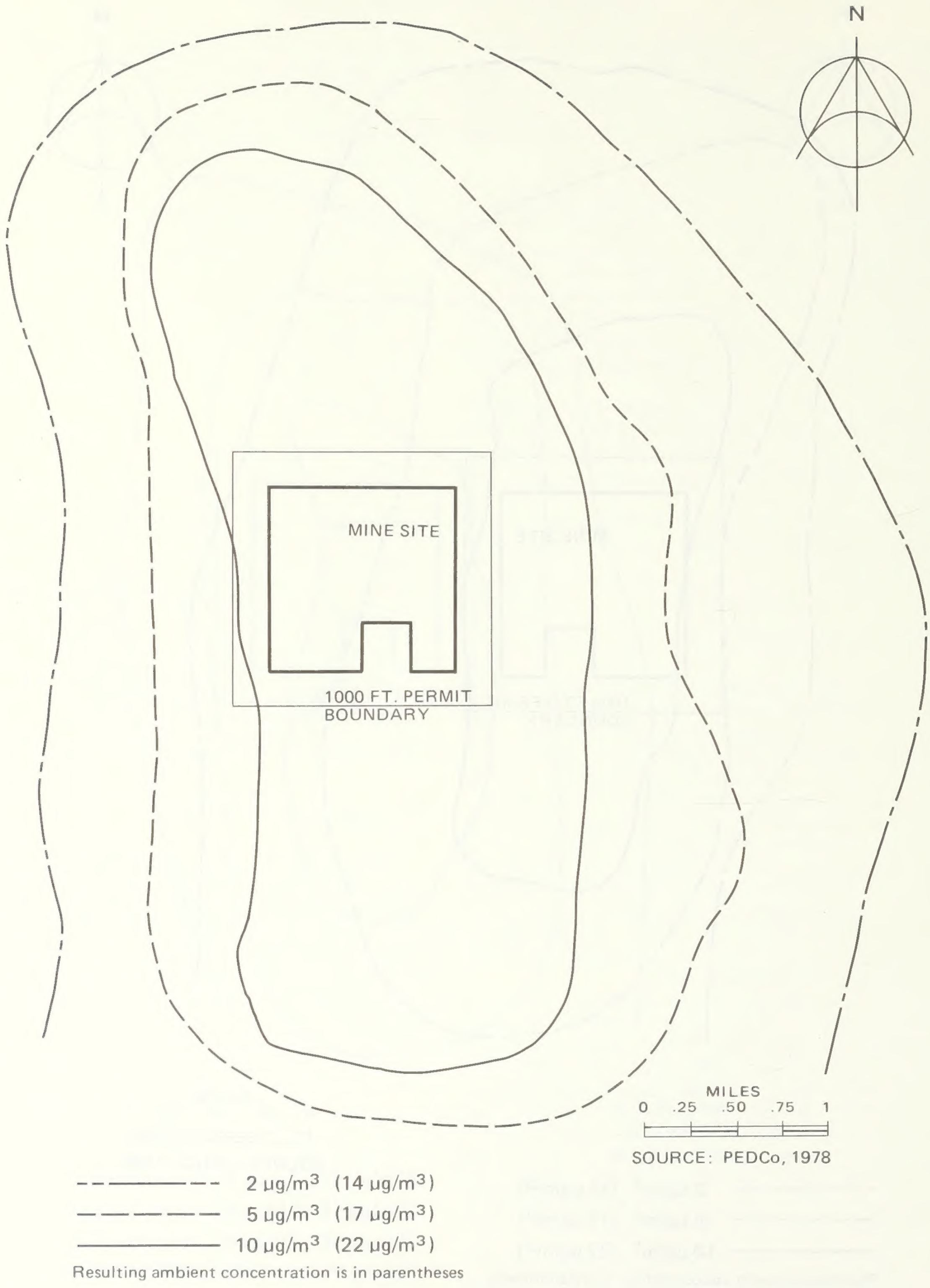


Figure BU3-3

ISOPLETH DIAGRAM SHOWING ANNUAL PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1990

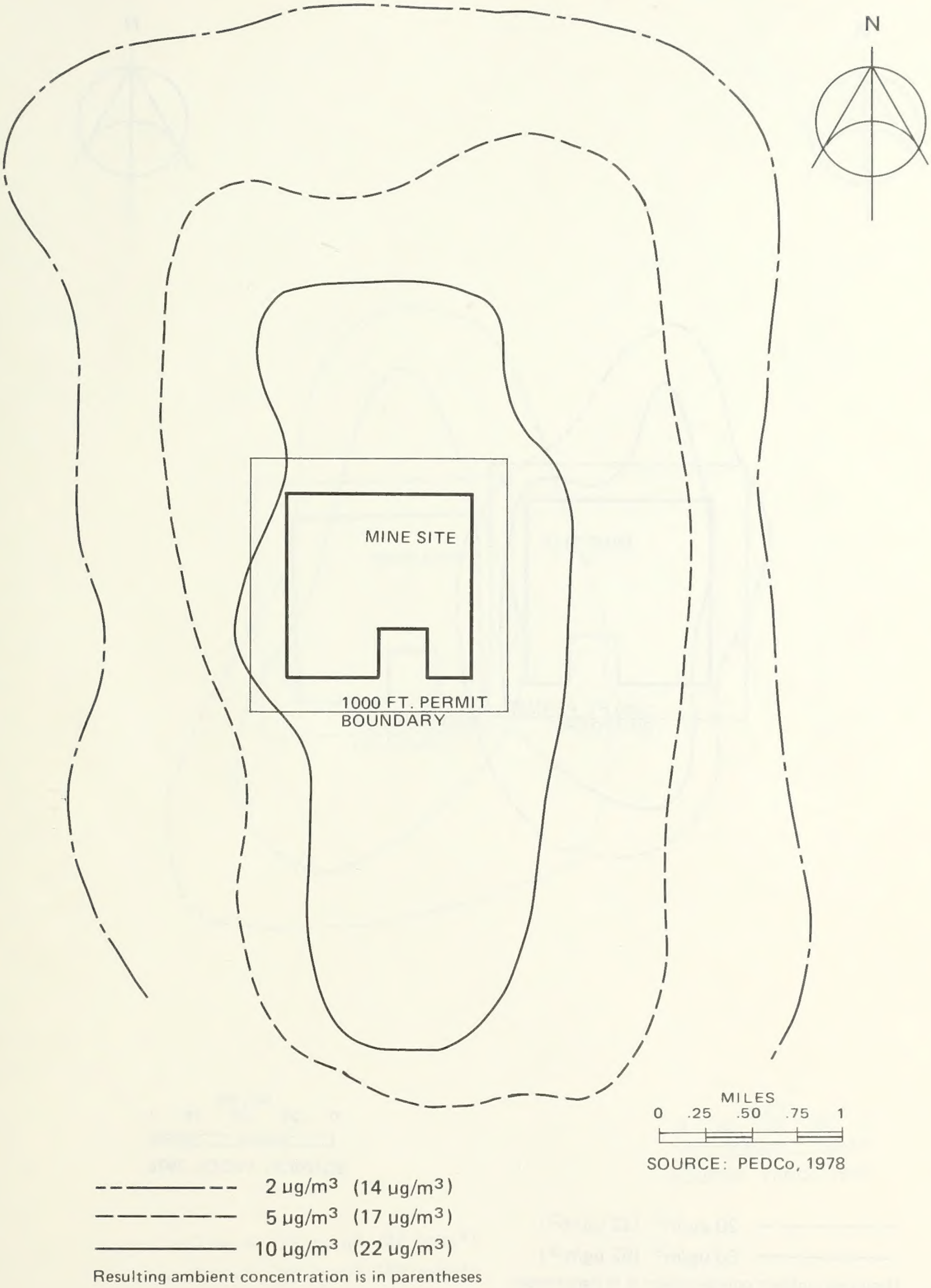


Figure BU3-4

ISOPLETH DIAGRAM SHOWING ANNUAL PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1999

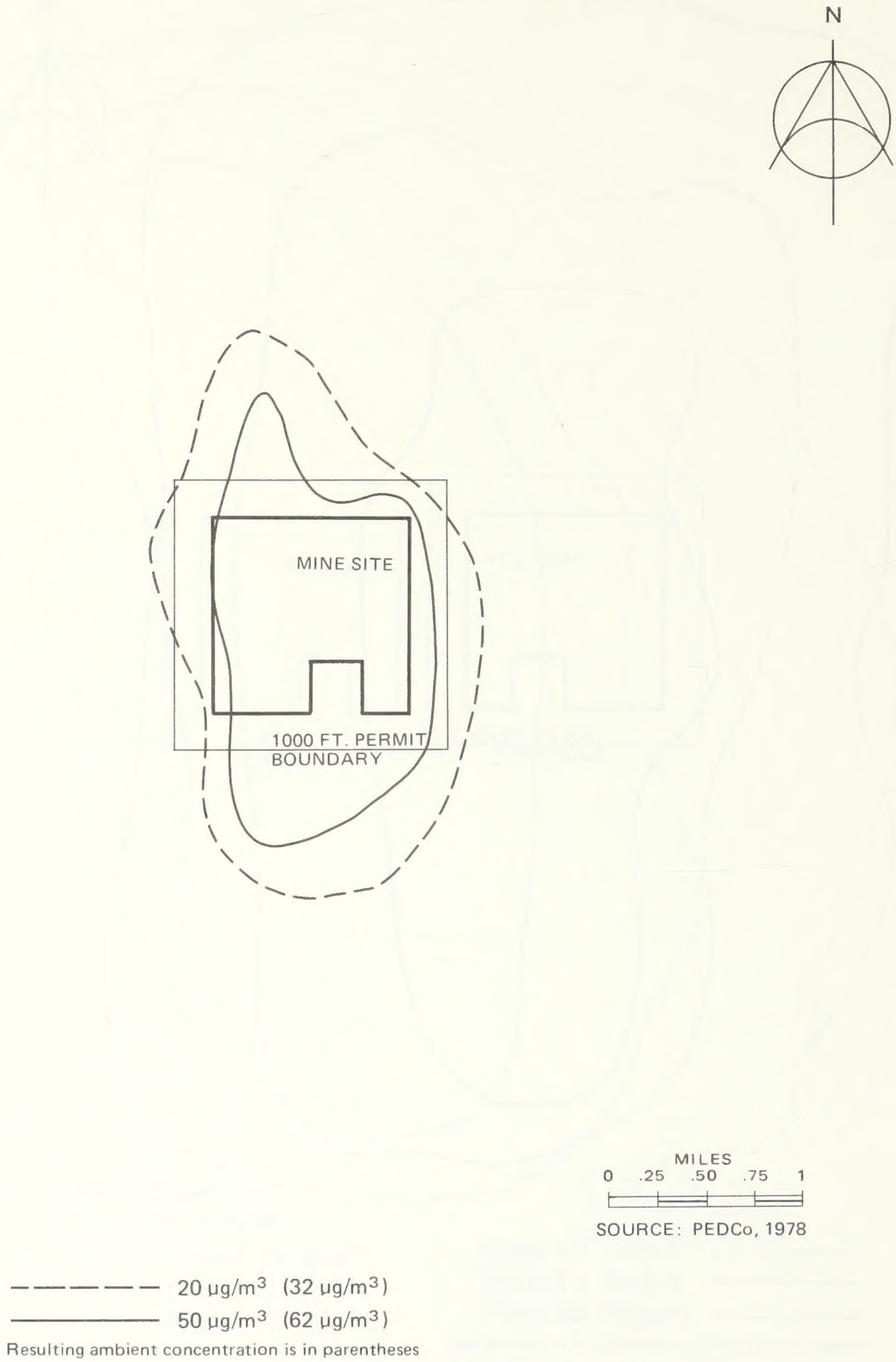


Figure BU3-5

ISOPLETH DIAGRAM SHOWING 24 - HOUR WORST CASE PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1980

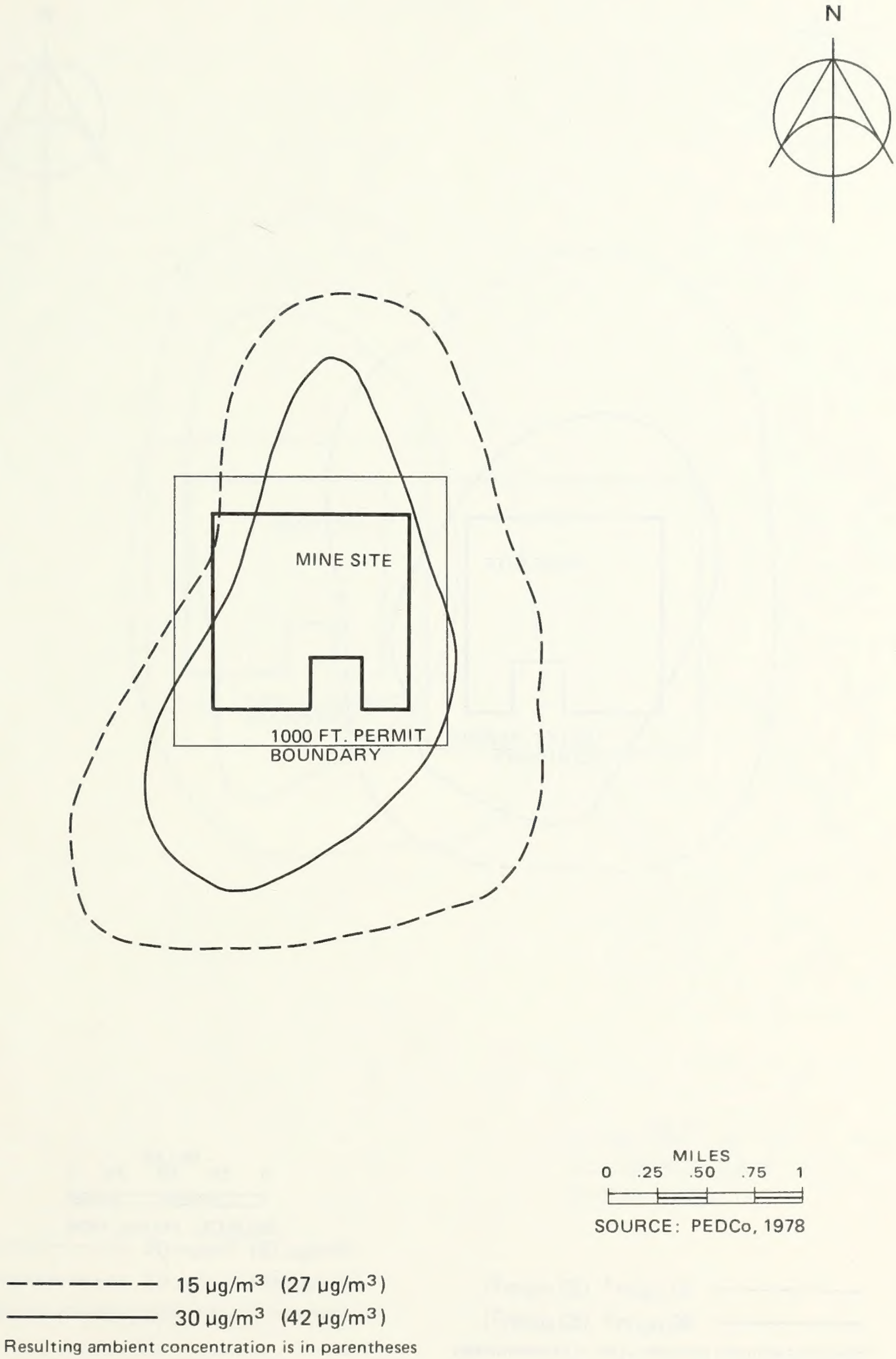


Figure BU3-6

ISOPLETH DIAGRAM SHOWING 24 - HOUR WORST CASE PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1985

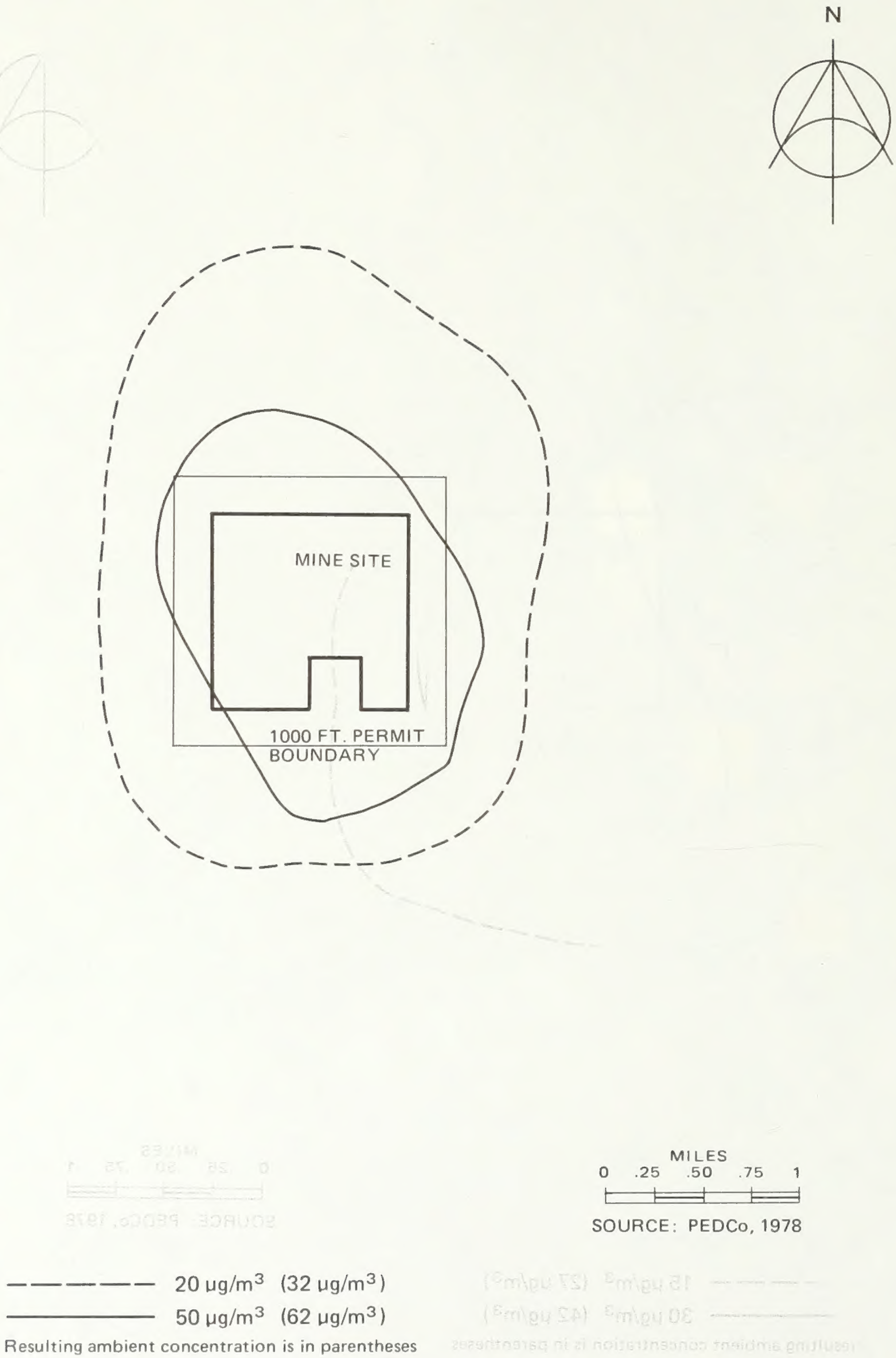


Figure BU 3-7

ISOPLETH DIAGRAM SHOWING 24 - HOUR WORST CASE PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1990

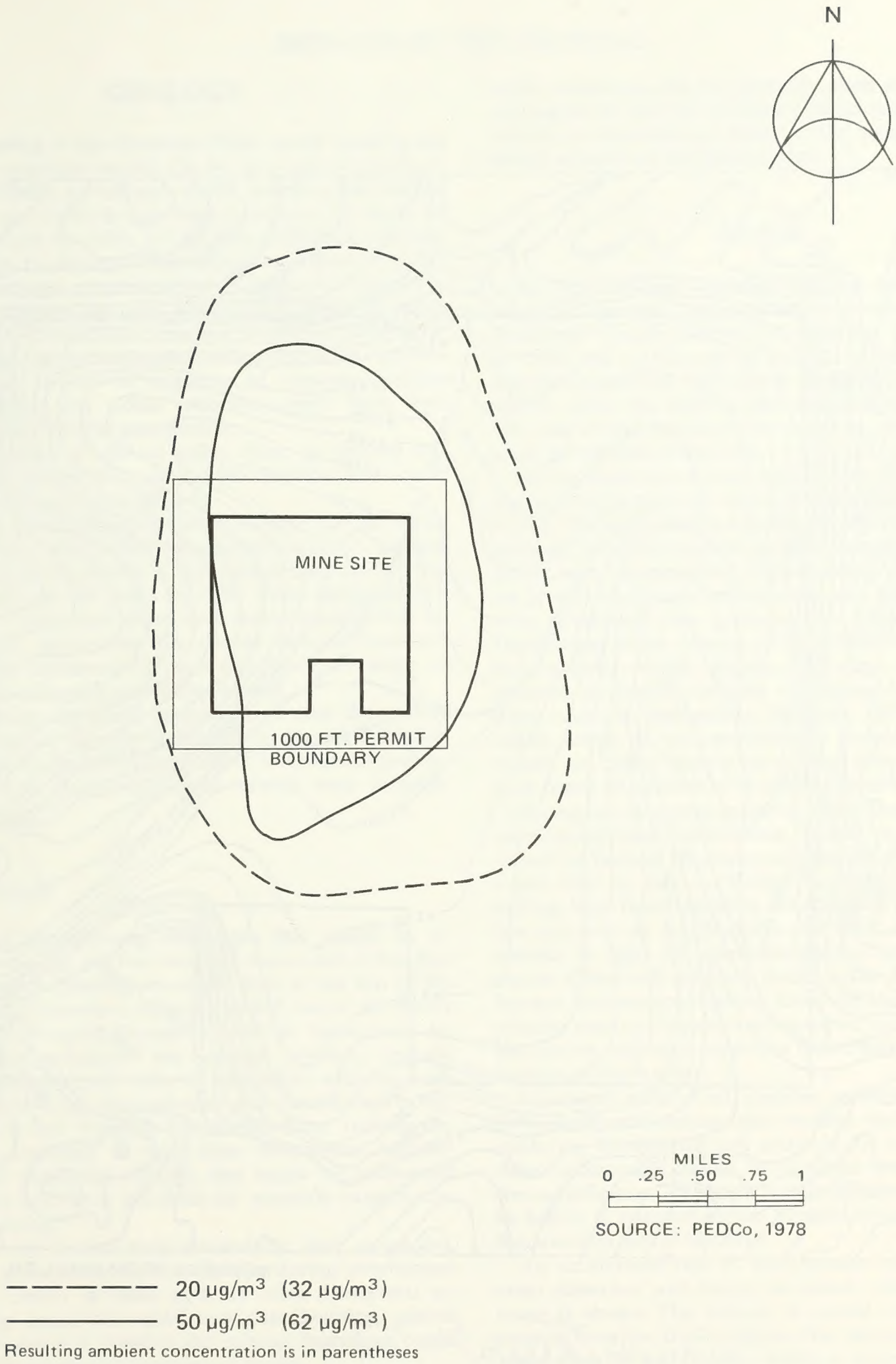
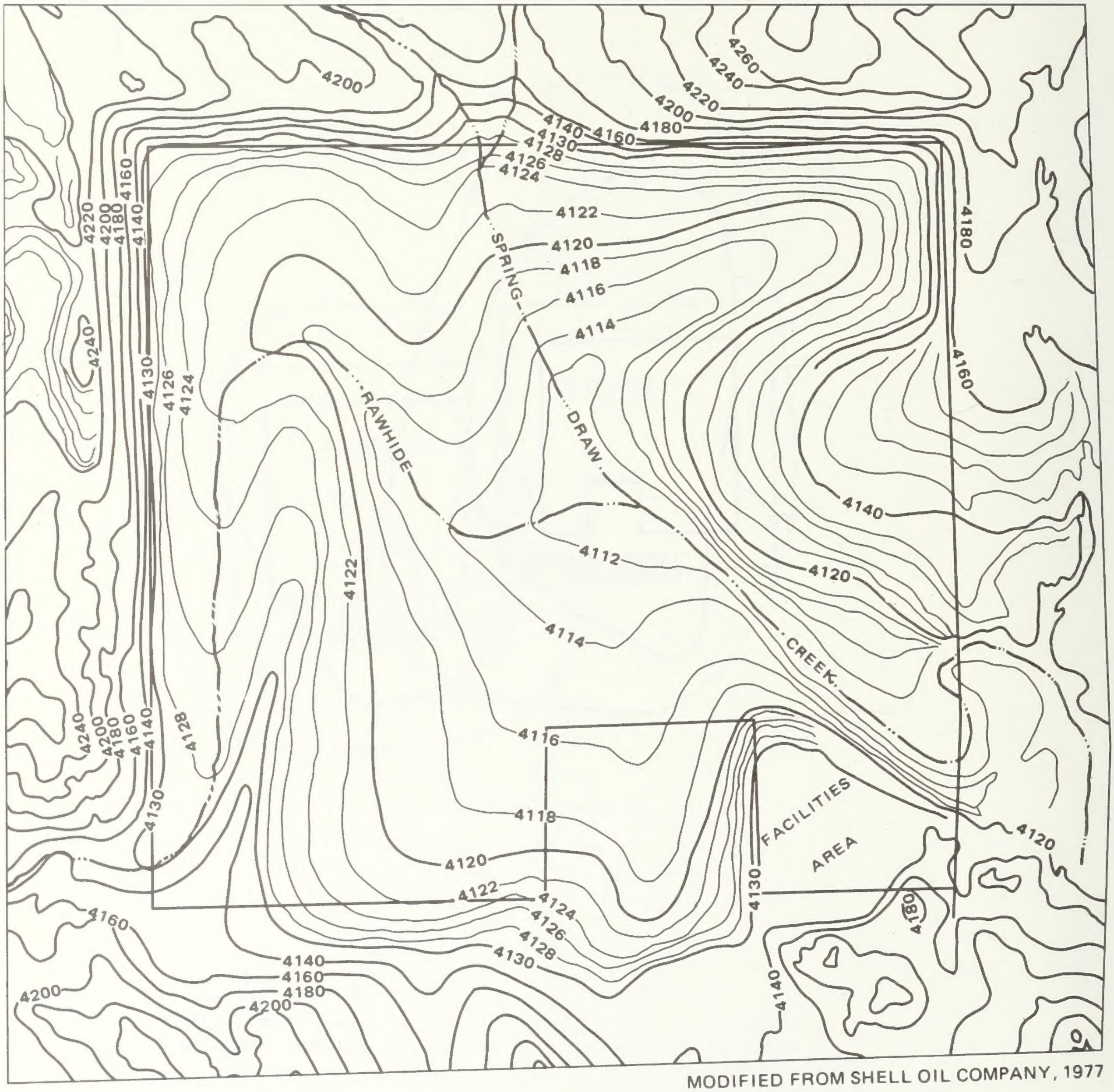


Figure BU3-8

ISOPLETH DIAGRAM SHOWING 24 - HOUR WORST CASE PREDICTED AND RESULTING AMBIENT PARTICULATE CONCENTRATIONS FOR 1999



MODIFIED FROM SHELL OIL COMPANY, 1977

Contour Interval - 2 feet

Figure BU3-9
TOPOGRAPHY OF THE MINE SITE AFTER RECLAMATION

IMPACTS OF THE PROPOSAL

GEOLOGY

Strip mining at the Buckskin Mine would result in the loss of the geologic record. On the area which would actually be mined, an average of 208 feet of strata, including the coal, would be lost over an area of 21 acres by 1980, 257 acres by 1985, 377 acres by 1990, and ultimately 658 acres by the end of mine life. In addition to physical loss of strata, about 2 miles of contacts between the coal and the overlying and underlying formations, which are the basis for geologic mapping, would be covered by fill and thus lost to future observation and study. A beneficial impact would be exposure of geologic sections during mining that would otherwise never have been available for scientific examination.

About 1½ miles of alluvial valley floor, as defined by the Surface Mining Control and Reclamation Act, would be disturbed (see Figure BU2-4).

Because replaced spoil settles over time, ground stability is altered where surface mining has occurred. Ground stability would be altered to an average depth of 125 feet over an area of 658 acres by 2001 when reclamation is complete. This could affect both future construction on and seismic exploration for deeper mineral resources through the reclaimed fill (see Chapter 4, Geology, of the Regional Environmental Statement).

Considering the small percentage of area that would be disturbed at the site compared to the total Eastern Powder River Basin (.01% by 2001), both loss of geologic record and decreased ground stability seem insignificant.

Paleontology

Potential fossil-bearing formations that would be affected by mining are the two coal seams and a few feet of interburden (totaling about 107 feet) at the top of the Fort Union Formation, as much as 215 feet at the lower part of the Wasatch Formation, and all Quaternary deposits. Paleontological loss would probably include pollen and plants, especially in association with the coal, and possibly some invertebrates and vertebrates in the Fort Union and Wasatch formations. Plant remains are relatively abundant in both these formations. Invertebrate and vertebrate remains that might be uncovered would not have been available for scientific examination prior to mining.

Quaternary fossils, both invertebrate and vertebrate, could be disturbed or lost at the site during overburden removal. Fossils of these ages are often discovered by excavating operations—road and dam building, gravel pits, etc.—and it is possible that mining operations could result in discoveries of Quaternary fossils.

Paleontological material throughout the region could be lost due to increased unauthorized fossil collecting and vandalism as a result of increased regional population. The extent of this impact cannot be presently assessed due to a lack of specific data on such activities.

Due to the present lack of data and accepted evaluatory criteria for determination of significance, no meaningful assessment can be presently made as to the extent and nature of the loss of these paleontological values to science or education, or hence to the significance of potential impacts on the fossil record.

SOILS

All developments (surface mining facilities, access road, railroad spur, and population increases) would cumulatively disturb soils on 715 acres by 1985; 835 acres by 1990; and 1,116 acres by the end of mine life (2000). The disturbance on 1,071 acres would be of a temporary nature, since the land would eventually be reclaimed. The loss of soil productivity would be permanent on 45 acres by the end of mine life.

Mining activities would impact soils by alteration of existing soil properties through disturbance and mixing of soil. These properties include soil microorganism composition, structure, texture, organic matter content, infiltration rate, permeability, water-holding capacity, nutrient level, soil-climatic relationships, and productivity that have developed over geologic time (Brady 1974, U.S. Department of the Interior 1975, 1976a). Stockpiling surface material would degrade biological, chemical, and physical properties, causing reductions in productivity when used in reclamation (Monsen 1975). The established levels of soil productivity would be lost and would not fully recover to present levels in the long term based on analysis of the Buckskin site.

Mining could expose material which contains chemical constituents (such as selenium, boron, or uranium) that would be harmful to plants and animals. These materials could exist in the overburden material. According to drilling logs, these materials are absent or present in very low amounts on the Buckskin site. This data seems reasonable in light of other information collected in the region. Other soil materials found in the area that would hamper reclamation include those of high alkalinity or salinity; sand or clay-textured material; and material with low cation exchange capacities (see Chapter 2 for identification of these soils).

Accidental spills of oil, gasoline, and other toxic materials could contaminate and sterilize the soil horizons, rendering the affected soil unusable for reclamation, but these occurrences would be localized and of little relative significance. Any such contaminated material would be buried as required by the Surface Mining Control and Reclamation Act (SMCRA).

An accelerated rate of wind erosion would occur on areas disturbed and being reclaimed, where vegetative cover is absent. The amount of annual soil loss to wind erosion from the Buckskin site after mining begins would range from 85 to 110 tons, which is an increase of 70 to 90 tons per year over erosion rates from the undisturbed site.

Between the time the land is reshaped during reclamation and the time when vegetation is reestablished, soil would be subject to an accelerated rate of water erosion. The rate of water erosion on areas with recently redistributed topsoil would range from 10 to 30 tons per acre

per year (calculated using Musgrave's Equation, Bureau of Land Management Manual 7317.22A) depending on such variables as slope and climatic conditions. This is an increase of 5 to 25 tons per acre per year over rates for undisturbed land.

If a 10-, 25-, 50-, or 100-year flood were to occur when areas are in the process of being reclaimed, additional erosion would occur, resulting in large amounts of soil loss and postponement of successful revegetation.

Reclamation of surface mining and associated facility areas would cumulatively occur on an estimated 790 acres by 1990 and an estimated 28 acres yearly thereafter (refer to Table BU1-3). Suitable topsoil material, steep slopes, aspect, surface manipulations, and climate are important variables of reclamation success. The limited amount of good to fair soil material, moderately steep slopes, and soils that are poor for reclamation are evident on the Buckskin project in a number of mapping units (refer to Chapter 2, Soils).

During reclamation, topsoil would be evenly spread over the disturbed areas. Thus, areas deficient in topsoil prior to mining would gain topsoil from sources with a surplus. The result would be some increase in soil productivity in these deficient areas but not enough to offset reduction of soil productivity on the major portions of disturbed acreage.

In all likelihood, based on reclamation efforts at nearby sites in Montana and Wyoming, there would be a strong response by seeded vegetation on the reclaimed area during the first decade or two after reclamation, if climatic conditions are average or above average during this period. The ground cover of living plants on the revegetated area should equal or exceed 90% of the ground cover of the reference area (a control plot of undisturbed ground) for more than two growing seasons during these early years as required under regulations of the Surface Mining Control and Reclamation Act. However, there would probably be a long decline in productivity in later decades as the vigor of the planted species declines on the overall thinner soil than existed prior to mining (see Table BU3-8). Since there are few soil-forming processes going on in the Powder River Basin under today's climate, overall soil productivity on the Buckskin site in later decades would remain at 87% of premining productivity for an indefinite future period.

The quality and quantity of "topsoiling"material and change in soil productivity after reclamation are quantifiable through the land capability and range site systems. The land capability and range site classification systems are nationally accepted methods for determining agricultural land potential prior to major disturbance, such as mining.

The use of these systems in analyzing the Buckskin reclamation plan is based on the assumption that the restored landforms and recreated soils will perform like soils which occur naturally in the existing environment. This assumption has not been proved or disproved on mined land as yet due to the short time period that these systems have been applied to mined lands.

The calculation of postmining productivity requires an assessment of the existing natural soils to determine how many acre-feet of suitable material are available for reclamation use (see Tables BU3-6 through BU3-8). Our analysis, using these systems, indicates that *long-term* soil productivity on the Buckskin site would be 87% of premining productivity. We therefore disagree with Shell's contention that they can recreate 100% soil productivity.

For a more complete discussion of the land capability and range site systems, see Chapter 2, Soils, of the Regional Environmental Statement.

WATER RESOURCES

Groundwater

The assessment of impacts on groundwater is based on a mine plan written before enactment of the Surface Mining Control and Reclamation Act of 1977. Alluvial valley floors as defined by the act occur on the leasehold; therefore, stripping of the floors would have to comply with the standards established by the act.

Two types of impacts would result from mining: those that are a direct result of mining and those that occur after reclamation. Impacts related to mining are those caused by the removal of existing aquifers and the increased use of groundwater by industry and municipalities.

The shallowest aquifers, or potential aquifers, in the area are the alluvium, overburden, and coal. These would be removed during mining, and water levels in adjoining, undisturbed beds would be lowered as the mine would become a discharge point. The groundwater flow into the mine predicted by the applicant is reproduced in Table BU3-9. Two of the assumptions on which the flow was estimated are that the cone of depression in the coal would extend approximately 3 miles, and that the cone of depression in the sandstone (overburden) aquifer would extend 1,000 to 1,500 feet. Approximately 40,000 gallons per day of the flow would be required for dust suppression. The remainder of the inflow would be pumped into Rawhide Creek (or its bypass channel) via settling ponds. The quality of water pumped into Rawhide Creek would be the same as that of the groundwater (see Tables BUA-1 through BUA-5 in the Appendix).

Additional groundwater supplies would be developed for potable water (4,655 gallons per day), fire protection, and plant water (55,000 gallons per day). The water for potable supply would probably be from the Fort Union Formation. The cone of depression around the well would be negligible because of the small quantity of water required (less than 5 gallons per minute). The fire protection and plant water probably would be drawn from the same well, but a deeper well in the Lance Formation and Fox Hills Sandstone could be used. Withdrawal of water for fire protection and plant uses would not affect groundwater supplies, since no other wells are close to the mine site.

TABLE BU3-6

VOLUME AND QUALITY OF TOPSOIL MATERIALS BEFORE MINING

Series	%	Acreage	Topsoil Volume (acre-feet) Good	Fair	Poor
Arvada	6	64		21	299
Bankard	3	32		0	160
Bowbac	36	386	127	903	
Haverson	6	64	32	224	64
Olney	19	203		879	0
Renohill	9	96		48	144
Shingle	7	75	25		98
Samsil	7	75		30	63
Rock Outcrop	7	75	---	-----	---
	100	1,071	184*	2,105*	828*

* A total of 3,117 acre-feet of good, fair, and poor "topsoil" exists on the mine site, of which approximately half is recoverable. This yields 1,558 acre-feet of "topsoil" to be spread over entire reclaimed area. "Topsoil" as used in this analysis refers to both the surface soil and subsoil, that is, the A, B, and usually the C horizons in soil morphological terms. Approximately half the "topsoil" is considered recoverable due to the undulating nature of the contact between soil material and overburden and the usual result when the soil salvage operation is carried out with large machinery.

TABLE BU3-7

LAND CAPABILITY AND RANGE SITE COMPARISON

Land Capability Classification	Acres Present	Acres After Reclamation
IV	96	
VI	750	1,071*
VII	150	
VIII	75	
Total Acres	1,071	1,071

Range Site	Present	After Reclamation
Clayey	96	
Lowland	96	
Sandy	590	
Saline	64	
Shallow clayey	75	
Shallow loamy	75	1,071
Rock outcrop	75	
Total Acres	1,071	1,071

*Shallow soils are usually placed in Capability Classification VII. In this case, after reclamation, the replaced overburden may be crushed to the point where it would be more receptive to root growth than the undisturbed overburden. Therefore, this reclaimed land should rate one capability class better than a typical shallow soil.

TABLE BU3-8

POTENTIAL FORAGE PRODUCTION AT PRESENT

Range Site	Yield (lb/ac/yr)*	Acres	Total Yield (lb/yr)**
Clayey	1,300	96	124,800
Lowland	2,500	96	240,000
Sandy	1,600	590	942,400
Saline lowland	500	64	32,000
Shallow clayey	900	75	67,500
Shallow loamy	900	75	67,500
Rock outcrop	0	75	0
			1,474,200***

POTENTIAL FORAGE PRODUCTION AFTER RECLAMATION

Range Site	Yield (lb/ac/yr)*	Acres	Total Yield (lb/yr)**
Shallow loamy	1,200****	1,071	1,284,000***

* Pounds per acre per year.

** Pounds per year.

*** The difference between these total yields represents a 13% loss in productivity after reclamation.

**** The average yield for a shallow loamy range site is 900 lb/ac/yr of air-dry forage. This reclaimed site may produce a forage comparable to the low end of a loamy range site due to the altered nature of the replaced overburden. This rationale is explained in Table BU3-7. At this time, we cannot project exactly how plant root growth, plant nutrient availability, and water movement would respond to the altered overburden.

TABLE BU3-9

ESTIMATED GROUNDWATER INFLOW TO BUCKSKIN MINE FOR VARIOUS STAGES OF DEVELOPMENT
(Data furnished by applicant.)

Development Stage (Year)	Water Level Altitude (Feet)	Pit Floor Altitude (Feet)	Range In Gradient (Feet/Mile)	Estimated Water Inflow (Gallons/Minute)
1-2	4140-4150	3990	50-100	220
3-4	4150-4160	3975-3980	40-160	400
12	4130-4140	3940	60-70	190
16	4130	3920	70	260

IMPACTS OF THE PROPOSAL

During the first year of operation, coal production would be 2 million tons per year, after which it would increase to a maximum of 4 million tons per year for the 20-year life of the mine. Assuming 18.25 acre-feet per year per million tons of coal mined, water use would be 73 acre-feet per year.

There would also be an increase in demand for water for municipal supplies to provide for the increased population. The present well field for Gillette, the major population center, is capable of supplying the present population. The city is currently studying the feasibility of developing water from the Madison Limestone about 40 miles northeast of town.

When the mined area is reclaimed, the spoil would become at least partly saturated and constitute a new water table aquifer, and groundwater flow would be generally similar to the present system. Because the land surface would be significantly lower throughout the area, the water table would be closer to the surface in some places, increasing the area in which there is a potential for discharge from groundwater by evapotranspiration. The water table gradient would remain towards the creek; however, flow paths would be affected by the location of haul roads if they are constructed so that highly compacted, fine-grained material is nearly continuous in the vertical.

Rahn (1976, p. 54) states,

> Water in spoils was found to be significantly more highly mineralized than natural ground water in terms of total dissolved solids, calcium, magnesium, and sulfate. Spoils water exceeds the recommended drinking water limits in these and other ions (manganese and cadmium), and it is doubtful that the water could be used for long-term irrigation.

If there is increased evapotranspiration from groundwater, this would cause an additional increase in dissolved solids in the water.

Water levels in the coal in unmined areas would probably recover to nearly their former levels, because the face of the unmined coal would be covered with overburden that may have a transmissivity similar to that of the coal it replaces. However, water levels in the overburden at elevations above 4,120 feet would be permanently depressed, because this is the elevation to which much of the area would be reclaimed.

Surface Water

Soil which is broken up and streams carrying higher sediment loads leave more soil surface exposed to the leaching and dissolving process of the water. Surface flow seeping from spoils and flow carrying added sediment from spoil would most likely contain higher levels of dissolved minerals than premining water. Surface flow originating on the mine area during the life of the mine would probably cause only minor impact downstream from the mine. Such surface flow could originate as seepage from overburden storage piles and temporary water impoundments, and as runoff from heavy rainfall or snowmelt. It would probably be heavily laden with sediment and be of very poor chemical quality. The amount of this flow, however, would be small compared to the total flow running through the area via Rawhide Creek.

Little or no increase in stream sediment is expected due to the approximately 13% increase in channel velocity between the natural and the bypass channels, as long as the design flood of about 1,000 cubic feet per second (cfs) is not exceeded. A flood of this magnitude, however, has almost a 10% chance of occurring in any one year (mean of computations according to Lowham 1976 and Hodson et al. 1973), or a chance of occurrence of 52% by 1985, 72% by 1990, or 91% before mining is completed.

If overtopping of the bypass channel should occur, the channel could be breached, causing flooding of the mine area and subsequent escape of heavy silt-laden flow on down the natural channel. Sudden sediment loads beyond the carrying capacity of the natural channel during a particular flood would be deposited in the channel. This may cause increased flooding downstream (due to lowered channel capacity) and increase the silt supply, which would be picked up by subsequent larger floods, thereby causing possible channel changes (resulting in loss of fields in crops, animals, buildings, etc., due to bank cave-ins) and increased silt deposits on fields when flows break out of their channels (causing loss of crops and pasturage). Flooding of the mine area might also carry accumulated chemical contaminants on downstream, possibly causing toxicity of crops and meadows, and subsequently affecting stock.

Increased water use of about 100,000 gallons per day (gpd) during the life of the mine is believed insufficient to impact the area. The increased water use of the expected 133 mine employees and the resulting wastes are expected to contribute to the total regional impacts. No impact in the area of the mine is foreseen, however.

Mining would eliminate the present groundwater system down to the bottom of the coal. The postmined water table is expected to be slightly farther below the land surface than the natural water table, according to the applicant. The former horizontal, more permeable rock shelves and lenses, which used to divert small quantities of water to the stream bed, would be destroyed. These two conditions point to the probability of the destruction of the premining stock and wildlife point-watering sources. This would, in turn, eliminate or discourage grazing within the area, thereby lowering the beneficial yield of the land, and consequently not bringing the land back to its full premining productivity.

If the postmined water table is above the land surface (or if settlement causes the land surface to sink below the water table), the resulting pond or lake would probably fill with water of very poor chemical quality. The total dissolved solids in groundwater seepage in the premined creek bed vary between 4,000 and more than 6,000 milligrams per liter (mg/l) between flushing by storm flows. This is generally higher than that recommended for stock watering. The postmining water could be of poorer quality.

Overburden settlement is not believed to be a problem until mining is complete and the reclaimed topography is finished. The mining and reclamation plan shows no large shallow ponding; however, our analysis indicates that over a period of time (undeterminable), the overburden would settle, causing a depression varying from about 35 acres due to about a 3-foot settlement (value furnished by applicant) to about 240 acres if the final settlement should amount to as much as 10% or 20%. Ponding in this depression would be ephemeral (would occur as a result of streamflow from precipitation only) if above the groundwater table, and water would not be available for long periods as it had been formerly. In this case the water would be of better quality than before mining. Ponding would occur for longer periods if the ground surface settles below the water table. In this latter case, the pond most likely would amount to a leaching pond of very high mineral content, and the water would probably be of much poorer quality than before mining.

The pond also would amount to a silt trap which would lower the sediment discharge downstream from the mine for many years to come. Rawhide Creek and Spring Draw channels within the depression would probably start filling with the silt eroded from gullies (started at the interface of the reclaimed and undisturbed land) and with the silt normally carried off the undisturbed drainages. This would cause the channels to readjust to new paths across the mined basin. Silt trapped by the pond (which normally would have been carried on downstream if the stream had been in its natural state) could initiate an increased downcutting or eroding cycle downstream from the mine, since the silt-carrying potential of the high flows would be lowered. An abrading stream bed normally will initiate downcutting of tributaries and cause gullying along its banks. Another impact of such erosion downstream would be the partial loss of fields and hay meadows at a rate faster than that occurring naturally.

Before any permanent impoundment can be left on reclaimed land, determinations of water quality and quantity must be made, and the impoundment must be part of the approved reclamation plan.

VEGETATION

Terrestrial Vegetation

During the 20-year life of the Buckskin Mine, vegetation would be disturbed on a total of 1,116 acres (includes 45 acres disturbed due to population increase). Vegetation would be affected as shown in Table BU3-10. Vegetative types that would be disturbed by the different activities are shown in Table BU3-11.

Haul road dust and fugitive coal dust from coal mining, blasting, transporting, processing, and loading may be deposited on vegetation adjacent to the activity areas. Dust-covered vegetation would be less palatable to livestock and wildlife.

There would be an increased risk of man-caused fires due to equipment and workers in the area.

The length of impact of vegetation loss would depend on the success of reclamation. Due to soil texture, toxicity, or other factors, some small areas might be impossible to revegetate, making loss of vegetation a permanent impact. In some years, climatic conditions might prevent revegetation success, extending impacts of vegetative loss. As discussed in the Regional Environmental Statement (Chapter 4, Vegetation), initial reclamation attempts have met with apparent success in other locations in the region. The Belle Ayr and Cordero mines, for example, report success ratios of 90% to better than 100% of premining productivity, which meets the standards established by the Surface Mining Control and Reclamation Act. These reports are for plantings which began no earlier than 1973.

The same result may be expected for the Buckskin Mine for the first decade or two. However, a 13% loss in *long-term* productivity of vegetation has been projected based on a 13% loss in soil productivity. (See Chapter 3, Soils, for an explanation of this prediction.)

Vegetative type conversion to grassland from the other types is likely to occur on the reclaimed areas, since it would be difficult to reestablish the plant species indigenous to the area. The forage production capability of this grassland type is expected to be 87% of premining level for livestock grazing and 15% to 20% for wildlife habitat. The 13% reduction of grazing capacity for livestock would be due to the loss of soil productivity, and the 80% to 85% reduction for wildlife habitat would be due to loss of native shrubs and forbs. Reestablishment of native species is expected to occur through natural succession in not less than 30 years (University of Wyoming, Black Thunder Project Research Team 1976).

Hydrologic studies of the applicant's proposal indicate that an additional long-term impact to vegetation could occur from overburden settlement. Over a period of time (undeterminable) the overburden would settle, causing a pond varying from about 35 acres due to about a 3-foot settlement (value furnished by applicant) to about 240 acres if the final settlement should amount to as much as 10% to 20%.

Aquatic Vegetation

The proposed project would destroy the aquatic vegetation in Spring Draw and Rawhide Creek, if these areas are mined. Although the Buckskin mining and reclamation plan proposes to restore these drainages, it is unlikely that aquatic vegetation can be restored to premining conditions.

Surface runoff from disturbed areas would increase the sediment load in the restored or unmined portions of Rawhide Creek and Spring Draw. This increase would adversely impact the aquatic community by the suffocating and abrasive effects of increased siltation.

TABLE BU3-10

ACREAGE OF VEGETATION DISTURBED BY ACTIVITY AND ACREAGE RECLAIMED

Activity	Time Periods 1980	1985	1990	1990+*
Mining	21	257	377	658
Mine facilities	140	140	140	140
Access road	72	72	72	72
Railroad spur	72	72	72	72
Stockpiles	129	129	129	129
Population needs	45	45	45	45
Total	479	715	835	1,116
Acres reclaimed	0	0	14	1,071

* To end of mine life which is estimated to be the year 2000.

TABLE BU3-11

VEGETATION TYPES AND AMOUNT TO BE DISTURBED BY ACTIVITY (APPROXIMATE ACRES)

Activity	Playa Grassland	Sandhills Grassland	Big Sagebrush	Silver Sagebrush	Riparian	Cultivated	Total
Mining		111	266	177	52	52	658
Mine facilities	2	18	47	38	5	30	140
Access roads		5	33	20	2	12	72
Railroad spurs		1	44	14	5	8	72
Stockpiles	2	14	57	29	8	19	129
Total	4	149	447	278	72	121	1,071*

* An additional 45 acres of vegetation will be disturbed due to population increase, but it is impossible to quantify the vegetation types affected.

Endangered and/or Threatened Species

No plants which have been identified as threatened or endangered, or are proposed for such designation, are known to exist on the mine site (see Chapter 2); hence, no effect from mining would be expected.

FISH AND WILDLIFE

General Information

The Wyoming Game and Fish Department, under contract with the Bureau of Land Management, is presently studying wildlife distribution and density in the Eastern Powder River Basin. Estimated numbers of wildlife affected by the proposed Buckskin Mine may change as a result of the study.

By the end of mining, native vegetation would be stripped from 1,071 acres at the mine site; an additional 45 acres (probably near Gillette) would be permanently lost to urban expansion to accommodate population growth. The habitat losses that would occur at the mine site are: 447 acres of sagebrush-grassland (big sagebrush), 278 acres of silver sagebrush, 72 acres of riparian, 149 acres of sandhills grassland, 4 acres of playa grassland, and 121 acres of cultivated land. The 45 acres permanently lost because of population growth would most likely occur in the sagebrush-grassland habitat type. The impacts to fish and wildlife habitat and populations are summarized in Table BU3-12.

Fishery

No fishery is known to exist on or near the proposed mine site, hence no adverse impacts to fish would occur.

Wildlife

The impact of the proposed action on various groups or species of wildlife is represented in Table BU3-13. Numbers were calculated by multiplying the acreage to be disturbed by each species' estimated density per acre (see Chapter 2, Fish and Wildlife).

Estimates of breeding potential lost due to the proposed action will be made when the Wyoming Game and Fish Department data are available.

Birds

Projected bird losses are shown on Table BU3-13. Birds on the mine site would be displaced by destruction of their habitat to adjacent areas, where most would die due to competition for food and cover.

Endangered and/or Threatened Species. Because no endangered or threatened species are known to occur on the site, no adverse impact would be anticipated from the proposed project. In the event that such species are identified on the site at a later time, immediate consultation by the operator with the U.S. Fish and Wildlife Service would be required under Section 7 of the Endangered Species Act.

Mammals

Nongame. All of the small nongame mammals which are unable to flee, or which retreat to burrows for safety, would be destroyed by earth-moving equipment. Other species which are able to flee would move into areas adjacent to the mine site, where most would die due to competition for available food and cover.

Game. Mining activity would destroy antelope habitat and displace the antelope presently occupying the site, as shown in Table BU3-13. The number of antelope displaced would probably be lost due to competition for available food and cover. Entanglement in fence wires may cause additional antelope loss. Antelope may be trapped or their movement restricted by fences, preventing movement to sheltered areas during storms, or keeping them away from more plentiful food supplies or water. If fenced, the rail spur that would serve the proposed mine, in combination with the mine itself and the access road, would form a barrier between Highways 14/16 and 59. This would prevent any localized north-south movement between the highways and could lead to the loss of a large number of antelope. The increase in human population attributable to the Buckskin Mine would increase, by a small amount, possible antelope losses from collisions with vehicles, poaching, and predation by domestic pets.

Mule deer would be subject to the same impacts as stated for antelope, except that mule deer movement is not restricted by fences.

Endangered and/or Threatened Species. Because no endangered or threatened species are known to occur on the site, no adverse impact would be anticipated from the proposed project. In the event that such species are identified on the site at a later time, immediate consultation by the operator with the U.S. Fish and Wildlife Service would be required under Section 7 of the Endangered Species Act.

Amphibians and Reptiles

All amphibians and reptiles presently occupying the proposed site would be destroyed during the initial earth-moving phase of mining.

Endangered and/or Threatened Species. No adverse impact to any endangered or threatened species would be anticipated on the proposed Buckskin Mine site, since such species are unknown in the region.

TABLE BU3-12

SUMMARY OF IMPACTS ON FISH AND WILDLIFE RESOURCES ON THE PROPOSED BUCKSKIN MINE SITE

Classification of Impacts	Anticipated Impact of the Proposed Mine		
	None	Minor	Major
Fish and Wildlife Habitat			x
Carrying Capacity for Fish and Wildlife			x
Fish and Wildlife Populations			
Fishery			
Nongame	x		
Game	x		
Endangered and/or threatened	x		
Wildlife			
Birds			
Nongame		x	
Game		x	
Endangered and/or threatened	x		
Mammals			
Nongame		x	
Game		x	
Endangered and/or threatened	x		
Amphibians and Reptiles			
General		x	
Endangered and/or threatened	x		

TABLE BU3-13

NUMBER OF INDIVIDUALS LOST DUE TO PROPOSED BUCKSKIN MINE

	Estimated Density*	1980	1985	1990	End of Mine Life
Habitat destroyed (acres)		479	715	835	1,116
Nongame birds					
Song birds	1.57/Acre	752	1,123	1,311	1,752
Raptors	4.8/Sq. Mile	4	5	6	8
Game birds					
Doves	130.5/Sq. Mile	98	146	170	228
Waterfowl (mallards)	6.6/Sq. Mile	5	7	9	12
Nongame mammals					
Small mammals	3.8/Acre	1,820	2,717	3,173	4,241
White-tailed jackrabbits	5.0/Sq. Mile	4	6	7	9
Predators					
Red Fox	0.4/Sq. Mile	0	0	1	1
Badger	1.0/Sq. Mile	1	1	1	2
Game mammals					
Cottontail rabbits	3.3/Sq. Mile	3	4	5	6
Antelope	9.8/Sq. Mile	7	11	13	17
Deer	1.0/2 Sq. Miles	0	1	1	1

* Information supplied by Shell Oil Company 1977. The Wyoming Game and Fish Department, under contract with the Bureau of Land Management, is presently studying wildlife distribution and density in the Eastern Powder River Basin. The figures shown above may change as a result of the study.

CULTURAL RESOURCES

The Office of the Wyoming State Archeologist, acting on the behalf of the State Historic Preservation Officer, has recommended archeological clearance for mining of the Buckskin site. Stipulations to this clearance are shown in Chapter 4.

Overburden stripping at the mine site could destroy buried prehistoric sites of unknown significance.

The two known prehistoric sites (48 CA 16 and 48 CA 17) lying within the area that would be mined have been studied and recorded; there is essentially little or no scientific data remaining in them to be impacted. Neither site is considered of National Register quality (Zeimens et al. 1978).

The remaining prehistoric sites (48 CA 89 and 48 CA 130) which lie in or near the proposed rail right-of-way have been studied, recorded, and collected in those areas where soil disturbance is proposed. If the proposed right-of-way is adhered to, there would be no futher impacts to these sites. As stipulated in the archeological clearance, further testing of both sites would be required if it becomes necessary to disturb them, or if their protection cannot be assured (ibid.). National Register eligibility of these sites cannot be determined without further testing.

Population increases in the region could lead to increased destruction of cultural resources due to unauthorized collection and vandalism; however the actual regional impacts caused by this proposed mine cannot be adequately assessed.

VISUAL RESOURCES

The impacts of the proposed Buckskin Mine on visual resources were determined using the Bureau of Land Management (BLM) contrast rating system. Contrast ratings describe how the proposed project would affect the existing landscape features (land surface, vegetation, and structures) as seen from U.S. Highway 14/16. Contrasts were evaluated for both the life of the mine and after reclamation. (See Table BUA-6, Appendix for Buckskin project contrast rating, and Regional Environmental Statement, Appendix B for discussion of visual resource management (VRM) classes.)

During the life of the mine, the contrast ratings for the land surface would exceed the limits of VRM Class IV. Contrasts with the natural landscape would be the open pit, service roads, railroad cuts and fills, power lines, and unshaped overburden. Soil color on roads and spoil piles and the exposed black coal seam would contrast with existing colors.

Contrast ratings for vegetation and structures would be acceptable for Class IV during the life of the mine. Unnatural edges of newly seeded areas and color variation in vegetation would cause only moderate contrasts. The surface facilities for the mine would be in the southeast corner of the permit area, and hence not visible from the highway. Only haul trucks and loaders at the western edge of the mine would be seen.

For the life of the mine, the permit area would be designated Class V, which is an interim classification indicating that rehabilitation is needed to restore an area to its natural character.

After mining is completed and reclamation is successful, contrasts would no longer exceed the limits for Class IV, and the area could be restored to its original class.

Changes in visual resources caused by the Buckskin Mine would not be isolated, but rather an extension of changes caused by other mines nearby. For example, Rawhide and Eagle Butte mines will already be operating 2 and 4 miles south of the Buckskin site respectively. Hence the impact of Buckskin would be considerably less than if it were the only intrusion in an otherwise open plain.

RECREATION RESOURCES

The most important impact of the proposed action on the recreation resources in Campbell County would be more people participating in and demanding recreation opportunities.

As a result of the proposed action, the population of the county is expected to increase by about 630 by 1990. Along with an increased population, the median family income in Campbell County by 1990 is projected to be 36% higher than the state average (Wyoming Recreation Commission 1975). Increases in population and income would mean increased stress on recreation facilities, which are already considered inadequate in Gillette (Table R2-13 in the Regional Environmental Statement). As a result, more services would have to be planned and managed in order to maintain an acceptable recreation experience. Maintenance costs would increase, as would costs of visitor safety measures and resource protection.

Also, overcrowding of city parks and facilities and increased use of the open plains by hunters, off-road vehicle users, and sightseers would decrease the quality of the recreation experience.

Therefore, although the population increase attributable to Buckskin would be minor (5%) compared to overall population growth in Campbell County by 1990, its impact would be significant.

On the Buckskin site itself, recreation opportunities are negligible now and would be little changed by mining. A minor reduction of huntable wildlife numbers would be the primary impact.

AGRICULTURE

Livestock Production

Grazing on the entire 1,760 acres (the total permit area) occupied by the mine, mine facilities, and ancillary facilities would be disrupted completely during the life of the mine. A total of 6,400 animal unit months (AUMs) of production would be lost during the life of the mine, with an average annual loss of 320 AUMs. The impact of grazing loss would be distributed between two operators.

The current operators have been bought out by industrial concerns but have leased back the land for grazing purposes. Once the Buckskin and other mining operations commence, the operators expect to go out of the grazing business completely in the area.

Once mining is completed, and if reclamation of the area is successfully accomplished, the stocking rate and grazing pattern are expected to return to near premining standards. This is consistent with the Shell Oil land use plan for the area, which assumes that the land would be returned to grazing use. However, forage production studies (Chapter 3, Soils) indicate that the potential forage production after reclamation would be 13% lower than present forage production. This would be a long-term impact. Current annual production is estimated to be 1,474,000 pounds of air-dry forage compared to an estimated 1,284,000 pounds after reclamation.

Surface water hydrology studies (Chapter 3) indicate that overburden settling would cause a pond to be formed varying from about 35 acres due to a 3-foot settlement to about 240 acres if the final settlement should amount to as much as 10% or 20%. This could cause an additional significant change in potential forage production after reclamation from the figure listed above, which was calculated without the pond. If the 35-acre lake is formed, total forage production would be reduced to 1,242,000 pounds per year of air-dry forage. This is a reduction of 16% from premining production and would be a long-term loss. If the 240-acre lake is formed, total forage production would be reduced to 996,000 pounds per year of air-dry forage. This is a reduction of 32% from premining production and would also be a long-term loss.

Haul road dust and fugitive coal dust from mining, blasting, transporting, processing, and loading may be deposited on vegetation adjacent to the mine. Dust-covered and damaged vegetation would be less palatable to livestock and wildlife.

The rail spur, access roads, and mine developments would divide grazing areas that are presently used as one continuous pasture. These obstacles to livestock movement could cause trailing (excessive use parallel to the obstacles) and overuse at points where the livestock are moved across to unused range.

The impact on range improvements would be primarily to watering facilities in Rawhide Creek and Spring Draw since mining activities would remove them. For reasons discussed in Chapter 3, Water Resources, it is unlikely that natural point-watering sources in Rawhide Creek and Spring Draw would redevelop in the recreated stream channels.

The alteration of flow of natural springs and the destruction of the riparian zones of Rawhide Creek and Spring Draw would affect the grazing of livestock and wildlife on these watershed areas. The degree of impact would vary according to the location of alternate water sources that may be developed.

Heavy sediment loads combined with flooding (Chapter 3, Water Resources) and possible channel changes could result in loss of crop fields and pasturage and increased silt deposits on fields downstream, resulting in further forage loss.

Farming

Disturbance of scattered areas currently used for cropland production is expected to occur on 121 acres. The 34 acres of barley and wheat production and the 87 acres of hay production are expected to be lost for the life of the mining project. This represents a loss of 960 bushels of barley, 60 bushels of wheat, and 26 tons of hay per year. The total loss would amount to 19,200 bushels of barley, 1,200 bushels of wheat, and 520 tons of hay during the life of the project. Shell Oil's current land use plans do not contemplate the restoration of these farming areas. The Surface Mining Control and Reclamation Act (SMCRA) requires disturbed areas to be restored to a condition which would be capable of supporting the premining use. Any alternative use must be approved by the regulatory authority. Shell Oil may be required to modify their reclamation plan.

MINERAL RESOURCES

The impact of mining to the mineral resources of the site would be the consumption and loss of the coal resource. During the 20-year life of the mine, an estimated 80 million tons of coal would be removed and an additional 4 million tons lost due to lack of recovery by present mining methods. An estimated 2 million tons would be removed by 1980, 22 million tons by 1985, and 42 million tons by 1990.

An unquantifiable amount of scoria, sand, and gravel would be used for mine facilities and possibly urban construction.

TRANSPORTATION NETWORKS

Railroads

A 6-mile private railroad spur to the Buckskin Mine site would be constructed from the terminus of the Burlington Northern-(BN)-owned portion of the 11-mile line originating at Donkey Creek, east of Gillette. One 100-car train per day would be required in 1980 to haul coal produced at Buckskin. Two trains per day would be required in 1985 and 1990. (Each car would carry 100 tons of coal.)

The proposed railroad spur would intersect State Highway 59 and some tertiary roads and could cause crossing hazards.

With increased rail movement from the mining site, noise levels would increase above existing levels.

Highways

Access to the proposed Buckskin Mine would be provided by construction of a 2-mile improved road from U.S. Highway 14/16 to the southeast corner of the lease. Commuter traffic on U.S. Highway 14/16 between the Buckskin Mine and Gillette would increase traffic flow and may increase the rate of highway deterioration. Based upon peak mine-related population increases (843) and a current vehicle registration rate of 945 per 1,000 population, the number of registered vehicles in Campbell, Converse, and Crook counties should increase by 794 by 1990 because of the Buckskin Mine (personal communication, Dee Herber, Wyoming State Department of Revenue 1977). No existing roads would be relocated during mining operations.

Other

The Gillette-Campbell County Airport could expect increased air operations (total departures and arrivals) because of traffic associated with the proposed Buckskin Mine. The mine-related peak population increase expected in Campbell County would be 730. This would mean an increase in both individual and corporate air operations and further strain the already inadequate passenger and freight capabilities of the airport. It is estimated that annual operations would increase by approximately 3,796 due to the approval of the proposed action. This is based on a 1976 total air operations to county population ratio of 5.2.

Power for the Buckskin Mine would be generated at the 330-Mw Wyodak Power Plant. There would be no disturbances to existing transmission lines from the mining operations, but 6 miles of new 69-kv power line would be constructed along Buckskin's railroad spur from the Rawhide Mines power line.

Given the capabilities of the present telephone system and the small increase in population due to Buckskin, the impact would be negligible.

SOCIOECONOMIC CONDITIONS

Introduction

The Buckskin Mine is only part of the development of coal (about 2% of that produced by 1990) and other energy resources possible in the Eastern Powder River Basin. It is important to remember that by their very nature, socioeconomic impacts may be of a regional scope, and not limited to a geographically defined site-specific area. Each individual energy development's socioeconomic impacts, when viewed alone, may be negligible, but its effect on cumulative impacts can be very significant. Thus, it is crucial for the reader to view this or any other site-specific analysis not only by itself, but also in terms of cumulative regional impacts.

Sociocultural Impacts

Population increases associated with the Buckskin Mine would contribute, particularly in Gillette, to regional social problems and changes in life-style already occurring. See Chapters 2 and 4 of the Regional Environmental Statement for a discussion of these sociocultural changes.

Economic Impacts

Population

Table BU3-14 compares population projections with and without the Buckskin Mine. Measurable population impacts due to Buckskin would be expected only in Gillette, Douglas, and Moorcroft. A handful of workers and their families might elect to live in the unincorporated settlement of Wright in Campbell County.

Although projected employment at the Buckskin Mine would be 150 in 1980 (25 construction workers, 125 permanent employees), the majority of these positions would probably be filled by local residents, limiting the overall population growth to 103. Virtually all (92%) of this incremental population is projected to reside in Gillette. Population growth due to Buckskin is projected at 459 by 1985, increasing to 843 by 1990. This includes population impacts of employment at the mine, as well as those of indirect and induced employment. Again, most of this population growth (83% as of 1985, 87% as of 1990) would probably occur in Campbell County, nearly all of it in Gillette. Much of the population increase in Douglas would be attributable to increased railroad employment generated by coal shipments from Buckskin. In addition, some Buckskin workers and their families would be expected to reside in Moorcroft.

Employment

Projected employment impacts of Buckskin Mine would be felt in three counties: Campbell, Converse, and Crook. The bulk of the employment would consist of workers at Buckskin, although by 1990 indirect and induced employment in the railroad, construction, services, and government sectors would make up a large share of the total.

Permanent employment at Buckskin would reach 133 by 1990, of whom 125 (94%) would be expected to reside in Campbell County, with the remainder commuting from neighboring Crook County. The construction work force at the mine, which would peak at 25 in 1980, would probably show a similar percentage distribution between Campbell and Crook counties. Shipments of coal from Buckskin would lead to a 25-person increase in railroad employment by 1990. About two-thirds of this additional rail employment would be expected in Converse County, and the remainder in Campbell County. In addition to employment at the mine and on the railroad, the creation of 134 additional jobs in the construction,

TABLE BU3-14

PROJECTED POPULATION IMPACTS OF BUCKSKIN MINE

County / City	1980 Population Without Buckskin	1980 Population With Buckskin	1980 Increment Attributable to Buckskin	1985 Population Without Buckskin	1985 Population With Buckskin	1985 Increment Attributable to Buckskin	1990 Population Without Buckskin	1990 Population With Buckskin	1990 Increment Attributable to Buckskin
Campbell	18,045	18,142	97	23,798	24,181	383	28,773	29,403	730
Gillette	11,875	11,970	95	17,625	18,000	375	22,600	23,322	722
Other Areas*	6,170	6,172	2	6,173	6,181	8	6,173	6,181	8
Converse	10,912	10,914	2	18,958	19,007	49	17,619	17,704	85
Douglas	5,692	5,694	2	12,330	12,379	49	10,919	11,004	85
Glenrock	2,733	2,733	0	4,138	4,138	0	4,210	4,210	0
Other Areas	2,487	2,487	0	2,490	2,480	0	2,490	2,490	0
Crook	5,434	5,438	4	6,292	6,319	27	6,809	6,837	28
Moorcroft	1,482	1,486	4	2,334	2,361	27	2,851	2,879	28
Other Areas	3,952	3,952	0	3,958	3,958	0	3,958	3,958	0
Total 3 Counties	34,391	34,494	103	49,048	49,749	459	53,201	53,912	843

Source: University of Wyoming 1978.

* Includes unincorporated settlement of Wright.

services, and government sectors would be expected; 112 would be in Campbell County.

Compared with regional employment projections, employment associated with Buckskin would represent a 2% increase in Campbell County, and less than a 1% increment in Converse and Crook counties. After 1980, many of the additional jobs created would probably be filled by immigrants from outside the region, due to the already extremely low local unemployment rates.

Income

Beginning in 1980, the Buckskin Mine would cause a relatively small but measurable increase in local earnings in Campbell, Converse, and Crook counties. Table BU3-15 summarizes the income impacts of Buckskin by county.

In 1980, the mine is expected to generate $7.1 million in additional earnings (measured in 1975 dollars) in the three counties affected, a 1% increase over earning levels foreseen without Buckskin. Virtually all of this increase would be accounted for by direct operating and construction manpower requirements at the Buckskin Mine, and it would be primarily restricted to Campbell County.

By 1985, earnings attributable to the mine (including railroad earnings) would reach $9.1 million (1975 dollars), approximately 1% above the earnings forecast without Buckskin. Almost nine-tenths of this incremental income would be concentrated in Campbell County, with the remainder divided between Converse and Crook counties.

In 1990, direct, indirect, and induced earnings attributable to Buckskin would be $14.2 million (1975 dollars), including railroad earnings. This would represent a 1.2% increase above the 1990 earnings forecast without the mine. Only $5.6 million, or 39% of the total, would be direct mine earnings; the remainder would consist of indirect and induced earnings in other sectors. More than 90% of all mine-related earnings would accrue to Campbell County.

Public Sector Impacts

Local Government

Buckskin-related popuation increases would increase the revenues at the disposal of local governments, while simultaneously increasing their operating and capital outlay requirements.

Principally due to the large property tax base at their disposal, local county governments and school districts should be able to meet the additional service and educational requirements of the Buckskin-related population. For municipal governments, the outlook would be mixed. Gillette's projected operating revenues appear sufficient to meet the city's operating requirements through 1990, both with and without Buckskin. However, Douglas would face a maximum operating shortfall of $1 million annually by 1985 without Buckskin. Moorcroft could be short by as much as $25,000 annually by 1990. Buckskin would have a minor additional adverse impact on Douglas' and Moorcroft's operating budgets.

Municipal governments vary in their ability to meet the capital costs of additional facilities, as discussed in Chapter 4 of the Regional Environmental Statement. Population increases attributable to Buckskin are not expected to necessitate any additional capital expenditures.

Local Services

Some local services (e.g., police and fire protection, water supplies, and sewage treatment) in Campbell, Converse, and Crook counties are already inadequate. The additional population growth attributable to the Buckskin Mine would, in some cases, cause additional marginal adverse impacts on these services.

Nearly all of the Buckskin-related population would be expected to reside in the incorporated areas of Gillette, Douglas, and Moorcroft. The marginal impact of Buckskin on county law enforcement and fire protection services would therefore be small.

Gillette is the only one of the three municipalities under consideration which would experience discernible service impacts as a result of the Buckskin Mine. However, these impacts would be quite marginal when compared with the impacts of the total population forecast. For example, without any new coal development, eleven additional police officers and three additional police cars would be required by 1990; the incremental population attributable to Buckskin would create a need for a twelfth new officer by 1990, but no new police cars.

To ensure adequate fire protection for the projected population, Gillette would need one additional pumper truck of at least 500-gallon-per-minute capacity, plus five more full-time firemen (or fifteen volunteers) by 1990. These requirements would not be affected by Buckskin.

Likewise, Gillette's water and sewage treatment needs, although substantial in themselves, would not be significantly affected by Buckskin. The city's projected water supply should be adequate through 1990. However, Gillette would need to expand its water treatment capacity from the present level of 2.5 million gallons per day (mgd) to over 10 mgd. Its current sewage treatment capacity (1.4 mgd) would have to be expanded to some 4.0 mgd by 1990 to meet the demands of the projected population.

Even without new coal development, Douglas would be faced with the problem of planning services for over 12,400 people by 1985 which would not result in long-term overcapacity when the population declines to under 11,000 after 1985. Further population increases due to the Buckskin Mine would not necessitate any increments to peak service levels. Conversely, the additional Buckskin-related population would not be sufficient to have any significant cushioning effect when the population declines after 1985.

The small increments in Moorcroft's population attributable to Buckskin would not appear to warrant any significant changes in the level of police or fire coverage,

TABLE BU3-15

INCREMENTAL EARNINGS ASSOCIATED WITH THE BUCKSKIN MINE, 1980-1990
(Millions of 1975 Dollars)

	Campbell			Converse			Crook			Three-County Total		
	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Minerals Extraction	2.2	4.3	5.5	0	0	0	0.1	0.1	0.1	2.3	4.4	5.6
Construction	4.5	0	1.2	0	0	0	0.3	0	0	4.8	0	1.2
Manufacturing	0	0	0	0	0	0	0	0	0	0	0	0
Railroads	0	0.1	0.1	0	0.2	0.2	0	0	0	0	0.3	0.3
Business/Consumer Services	0	2.8	4.0	0	0.2	0.2	0	0.2	0.6	0	3.0	4.8
Government/Education	0	1.0	2.0	0	0.1	0.1	0	0.1	0.2	0	1.1	2.3
Military	0	0	0	0	0	0	0	0	0	0	0	0
Totals	6.7	8.2	12.8	0	0.5	0.5	0.4	0.4	0.9	7.1	9.1	14.2

Source: University of Wyoming 1978.

or any expansion of the town's water supply or sewage treatment facilities beyond already projected needs.

Health Care

Table BU3-16 contains projections of the number of physicians, registered nurses, and dentists necessary to provide adequate health care to the populations of Campbell, Converse, and Crook counties. The impact of Buckskin-related population growth on these requirements would be insignificant. Despite the recent success of the Campbell County Hospital Board in recruiting five more doctors, the shortage of doctors would probably remain a critical problem in the three counties.

The shortage of doctors is one reason why the underutilization of hospital facilities in the three counties is expected to continue. Another reason is the relatively small size of the hospitals, which precludes offering some types of sophisticated treatment. (Hospital bed occupancy rates in Campbell, Converse, and Crook counties are 51%, 48%, and 16% respectively, compared with the nationwide average of 77%.) Many local residents travel to Casper, or even outside the region, for hospital care. For this reason, although Campbell County is currently building a new 55-bed hospital, hospital needs must be assessed on a regionwide basis.

Based on the current average regional hospital occupancy rate of 46%, the region would have an adequate supply of hospital beds through 1980. However, even with planned local hospital expansions, the region as a whole would experience a shortfall of 193 beds by 1990 (196 including Buckskin).

Education

Three school districts would experience Buckskin-related impacts on student enrollments: the Campbell County School District; Converse County School District 01; and the Crook County School District. The incremental impacts of Buckskin Mine on these three school districts are shown in Table BU3-17. These impacts are quite minor when viewed in the context of overall projected enrollment increases: an increment of 1.2% in Campbell County, 0.6% in Converse County 01, and 2.2% in Crook County.

These enrollment increases would not have any major effect on the capital facility requirements of the three school districts (see Chapter 4 of the Regional Environmental Statement).

Enrollment due to Buckskin would necessitate Campbell County's hiring up to 10 additional teachers by 1990. In Douglas and Crook County, the impact of Buckskin-related enrollment on long-term additional teacher requirements would be negligible.

Private Sector Impacts

Housing

Table BU3-18 shows projected housing demand with and without the Buckskin Mine in Gillette, Douglas, and Moorcroft. The incremental growth in housing demand attributable to Buckskin would vary from 0% to 0.4% annually, depending on the locality and the type of housing.

Based on comparisons with historical rates of growth in the local single-family housing stock, local builders appear capable of meeting the demand for single-family homes through 1990. However, Table BU3-18 measures only effective demand, i.e., households desiring *and* able to afford the high cost of single-family housing. In Gillette, the number of households desiring, but unable to afford, single-family housing is estimated at approximately 750 by 1990 (775 including Buckskin). In Douglas it is anticipated that 350 households (360 including Buckskin) would be unable to afford the single-family homes they desire by 1985. (If Douglas' population declines after 1985 as projected, it may cause a significant drop in housing costs, increasing the availability of single-family homes.) In Moorcroft, approximately 160 households by 1990 (no significant incremental impacts due to Buckskin) would be prevented from buying the single-family homes they desire by high housing costs.

Even at inflated production costs, the majority of the new mining employees would be able to qualify for single-family homes. Table BU3-19 summarizes the anticipated wage distribution of the workers at the proposed Buckskin Mine. More than half would have household incomes of over $20,000 per year, even if there are no second wage earners in the households. Most of the new employees in the service sector jobs indirectly resulting from the mine would be able to afford single-family units only if there are two or more full-time wage earners in the household and/or the cost of new housing is reduced.

The population growth directly and indirectly resulting from Buckskin would also increase demand for, and thus the likelihood of shortages in rental apartments, transient accommodations, and mobile home spaces.

TABLE BU3-16

PROJECTED HEALTH MANPOWER REQUIREMENTS

	1977 Physicians	Physicians Recommended Level*			1977 Registered Nurses	Registered Nurses Recommended Level**			1977 Dentists	Dentists Recommended Level***		
		1980	1985	1990		1980	1985	1990		1980	1985	1990
Campbell	9	18	24	29	53	63	84	101	4	11	15	18
Converse	6	11	19	18	29	38	67	62	2	7	12	11
Crook	2	5	6	7	11	19	22	24	1	3	4	4

Source: Wyoming Department of Health and Social Services 1977; personal communication, Larry Bertilson, State Health Planning Manager, 1978.

* Based on recommended standard of 1,000 persons per physician.
** Based on recommended standard of 285 persons per registered nurse.
*** Based on recommended standard of 1,600 persons per dentist.

TABLE BU3-17

SCHOOL DISTRICT ENROLLMENT PROJECTIONS

Enrollment Projections Without Buckskin

	1980				1985				1990			
	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total
Campbell Gillette	2,880	1,155	1,053	5,089	3,790	1,520	1,386	6,697	4,592	1,841	1,680	8,114
Converse Douglas	1,259	482	409	2,152	2,397	918	783	4,098	2,156	825	704	3,685
Crook Sundance	714	359	334	1,407	826	415	388	1,629	894	450	419	1,763

Enrollment Projections With Buckskin

	1980				1985				1990			
	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total	Elem.	J. H.	H. S.	Total
Campbell Gillette	2,895	1,161	1,059	5,116	3,892	1,561	1,423	6,877	4,693	1,882	1,716	8,292
Converse Douglas	1,258	461	410	2,151	2,410	923	787	4,121	2,163	826	706	3,698
Crook Sundance	713	359	335	1,408	829	417	389	1,637	897	451	421	1,771

Source: University of Wyoming 1978.

TABLE BU3-18

PROJECTED HOUSING DEMAND, 1977-1990

Community Housing Type	1977 Housing Stock	Average Annual Growth Rate of Housing Stock, 1970-77	Additional Demand for Housing Units, 1977-1990: Without Buckskin		With Buckskin	
			No. of Units	Average Annual Growth in Housing Stock	No. of Units	Average Annual Growth in Housing Stock
Gillette						
Single Family	1,623	5.2%	1,857	6.0%	2,007	6.4%
Multi-Unit	680	6.3%	486	4.2%	513	4.4%
Mobile	1,542	13.3%	1,492	5.3%	1,573	5.6%
TOTAL ALL TYPES	3,845	8.1%	3,835	5.5%	4,093	5.7%
Douglas						
Single Family	1,232	6.5%	721	3.6%	728	3.6%
Multi-Unit	207	0.7%	350	7.9%	353	8.0%
Mobile	349	24.8%	1,206	12.2%	1,228	12.3%
TOTAL ALL TYPES	1,788	8.2%	2,277	6.5%	2,309	6.6%
Moorcroft						
Single Family	147	NA	285	8.6%	296	8.9%
Multi-Unit	0	NA	63	---	65	---
Mobile	150	NA	230	7.4%	233	7.5%
TOTAL ALL TYPES	297	NA	578	8.7%	594	8.8%

Note: Two major factors were taken into account in compiling Table BU3-18: workers' personal preferences for different types of housing and their ability to pay for the type of housing desired. See notes for Table R4-16 in the Regional Environmental Statement for an explanation of these factors.

NA = not available.

TABLE BU3-19

ANTICIPATED INCOME DISTRIBUTION FOR EMPLOYEES AT THE PROPOSED MINE

Annual Income	Percent of Total Employees
$30,000 and above	2.5
$25,000-$30,000	12.5
$20,000-$25,000	50
$15,000-$20,000	25
$15,000 and below	10
Total	100

Source: Shell Oil Company 1977.

TABLE BU3-20

APPLICABILITY OF SURFACE MINING CONTROL AND RECLAMATION ACT (SMCRA) PROVISIONS TO IMPACTS OF THE PROPOSED ACTION

Reference Number	Description of Impact of Proposed Action	SMCRA Performance Standards Bear on Impact
Air Quality		
AQ-1	Generation of fugitive dust emissions would cause an increase in total suspended particulates (TSP)	No
AQ-2	Visibility would be reduced by increased TSP	No
AQ-3	Vehicle emissions would be generated	No
Topography		
TO-1	Smooth depression would result after mining	No
TO-2	Landforms would be altered during mining	No
TO-3	Some railroad and road cuts may remain after mining	No
Geology		
GE-1	Part of the geologic record would be lost	No
GE-2	Ground stability would be decreased	No
GE-3	Rock hunting would increase	No
Paleontology		
PA-1	Potential fossil-bearing strata would be lost	No
PA-2	Unauthorized fossil collecting would increase	No

TABLE BU3-20
(cont'd)
APPLICABILITY OF SURFACE MINING CONTROL AND RECLAMATION ACT (SMCRA) PROVISIONS TO IMPACTS OF THE PROPOSED ACTION

Reference Number	Description of Impact of Proposed Action	SMCRA Performance Standards Bear on Impact
Soils		
SO-1	Soil productivity would be reduced after reclamation	Yes (30 CFR 715.13)
SO-2	Soil productivity would be lost for new urban areas	No
SO-3	Soil productivity would be lost while areas are being mined	No
SO-4	Topsoil would be lost to erosion	Yes (30 CFR 715.16 and 715.20)
SO-5	Topsoil could be contaminated by toxic materials	Yes (30 CFR 715.16)
Groundwater		
GW-1	Water quality would be lowered in spoils after reclamation	Yes (30 CFR 715.17)
GW-2	Water levels would be lowered in adjacent aquifers during mining	Yes (30 CFR 715.17)
GW-3	A valley which may be designated as alluvial could be disturbed	Yes (30 CFR 715.17)
GW-4	Water levels would be nearer the surface in spoils	Yes (30 CFR 715.17 and 715.14)
GS-5	Infiltration and recharge would be altered in the spoil after reclamation	Yes (30 CFR 715.17)
GS-6	Coal and overburden aquifers would be destroyed by mining	No
GS-7	Consumptive use of groundwater could affect other users	Yes (30 CFR 715.17)

TABLE BU3-20
(cont'd)
APPLICABILITY OF SURFACE MINING CONTROL AND RECLAMATION ACT (SMCRA) PROVISIONS TO IMPACTS OF THE PROPOSED ACTION

Reference Number	Description of Impact of Proposed Action	SMCRA Performance Standards Bear on Impact
Surface Water		
SW-1	Surface water system would be destroyed by mining, water would be diverted around the mine	Yes (30 CFR 715.17)
SW-2	After reclamation, surface water system would be altered from existing characteristics	Yes (30 CFR 715.13, 715.14, 715.17)
SW-3	Shallow ponding could result after reclamation	Unknown
SW-4	Peripheral gullying could result after reclamation	Yes (30 CFR 715.13, 715.14, 715.17)
SW-5	During flooding, sedimentation would increase due to high stream velocities	No
SW-6	Breaching of bypass channel and impoundment would release low quality water downstream	Yes (30 CFR 715.17)
SW-7	Leachate and surface runoff could enter the surface water system during mining	Yes (30 CFR 715.17)
SW-8	Increased surface water use by new population would occur	No
SW-9	Water quality could be lowered by sewage effluents	No
Vegetation		
VG-1	Vegetative productivity would be reduced after reclamation	Yes (30 CFR 715.13 and 715.20)
VG-2	Vegetative productivity would be lost for new urban areas	No
VG-3	Vegetative productivity would be lost while areas are being mined	No

TABLE BU3-20
(cont'd)
APPLICABILITY OF SURFACE MINING CONTROL AND RECLAMATION ACT (SMCRA) PROVISIONS TO IMPACTS OF THE PROPOSED ACTION

Reference Number	Description of Impact of Proposed Action	SMCRA Performance Standards Bear on Impact
Vegetation (cont'd)		
VG-4	Species variety would be reduced	Yes (30 CFR 715.20)
VG-5	Vegetative productivity could be reduced by dust deposition during mining	No
VG-6	Fire hazard would be increased during mining	No
VG-7	Aquatic vegetation would be adversely affected	Yes (30 CFR 715.13, 715.14, 715.17)
VG-8	Vegetative productivity could be reduced by topsoil erosion	Yes (30 CFR 715.16 and 715.20)
Wildlife		
WL-1	Wildlife habitat quality would be reduced after reclamation (affecting populations and carrying capacity)	Yes (30 CFR 715.13)
WL-2	Wildlife habitat would be lost during mining	No
WL-3	Carrying capacity would be lost during mining	No
WL-4	Wildlife populations would be reduced	No
Cultural Resources		
CR-1	Known cultural sites could be damaged by mining activities	No
CR-2	Unknown sites could be uncovered and/or damaged by mining activities	No
CR-3	Cultural artifacts could be damaged or lost by increased unauthorized collecting	No

TABLE BU3-20
(cont'd)
APPLICABILITY OF SURFACE MINING CONTROL AND RECLAMATION ACT (SMCRA) PROVISIONS
TO IMPACTS OF THE PROPOSED ACTION

Reference Number	Description of Impact of Proposed Action	SMCRA Performance Standards Bear on Impact
Visual Resources		
VR-1	Visual quality on the mine site would be reduced from Class IV to Class V	No
VR-2	Visual quality in new urban areas would be reduced from Classes II, III, or IV to Class V	No
Recreation Resources		
RR-1	Use of recreation facilities would be intensified	No
RR-2	"Primitive" recreation quality would be reduced	No
RR-3	Conflicts between landowners and recreationists would increase	No
RR-4	Numbers of huntable wildlife would be reduced	No
RR-5	Mining and urban expansion would reduce the land use base	No
RR-6	Sightseeing of natural landscapes would be reduced	No
Agriculture		
AG-1	AUMs (carrying capacity) would be reduced after reclamation	Yes (30 CFR 715.13)
AG-2	AUMs would be lost while areas are being mined	No
AG-3	AUMs would be lost for new urban areas	No
AG-4	Forage productivity could be reduced by dust fallout	No
AG-5	Animal harassment and unintentional openings of enclosures would increase	No

TABLE BU3-20
(cont'd)
APPLICABILITY OF SURFACE MINING CONTROL AND RECLAMATION ACT (SMCRA) PROVISIONS
TO IMPACTS OF THE PROPOSED ACTION

Reference Number	Description of Impact of Proposed Action	SMCRA Performance Standards Bear on Impact
Agriculture (cont'd)		
AG-6	New rail and road access could split pastures and interrupt agricultural operations	No
AG-7	Surface water system alteration would affect agricultural operations	Yes (30 CFR 715.13, 715.19)
AG-8	Increased sediment release during floods would affect productivities	Yes (30 CFR 715.17)
AG-9	121 acres of cropland would be destroyed and not reestablished by reclamation	Yes (30 CFR 715.13)
Mineral Resources		
MR-1	Coal would be converted to electrical energy	No
MR-2	Some coal would not be recovered	No
MR-3	Sand, gravel, and scoria would be consumed in construction activities	No
Transportation Networks		
TR-1	Rail traffic would increase	No
TR-2	Street and highway traffic would increase	No
TR-3	Traffic and use of the Gillette airport would increase	No
Socioeconomic Conditions		
SE-1	City of Gillette would experience increased fiscal stress	No
SE-2	Housing requirements and needs would intensify	No
SE-3	Quality of life and character of Gillette and Campbell County would be changed	No
SE-4	Employment and wages would increase	No

CHAPTER 4

MITIGATING MEASURES

INTRODUCTION

The discussion and analysis of effectiveness for measures which would mitigate impacts resulting from mining and reclamation on the Buckskin site are presented in this chapter. There are two categories of mitigation which would bear on this project.

The recent enactment of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) and promulgation of regulations (Title 30 CFR Part 700) to implement the act require the mine permittee (Shell Oil Company) to revise and resubmit the mining and reclamation plan. The revisions are necessary to bring the plan into compliance with SMCRA. The first category of mitigation (SMCRA performance standards) represents an effort to anticipate the requirements (performance standards) of SMCRA which require revisions in the plan. To the extent possible, the performance standards are analyzed for their general effectiveness in mitigating specific impacts on the Buckskin site.

The second category of mitigation (committed measures) includes all those measures which are real, committed, and will be enforced. An analysis of the effectiveness of each committed mitigating measure is also included in this discussion.

Table BU4-1 at the end of this chapter summarizes the effectiveness of both categories of mitigation, and the impact remaining after mitigation (residual impact).

SMCRA PERFORMANCE STANDARDS

Postmining Use of Land (30 CFR 715.13)

All disturbed areas shall be restored in a timely manner to conditions that are capable of supporting the uses which they were capable of supporting before any mining or to higher or better uses if approved by the regulatory authority.

It appears from the calculations presented in Tables BU3-6 through BU3-8 that long-term soil productivity (and hence vegetative productivity) would eventually stabilize at 87% of premining levels on the Buckskin site, unless some modification of the reclamation plan raises the productivity. The methodology used to calculate this productivity is explained in Chapter 2, Soils, of the Regional Environmental Statement. Although the methodology has not been verified on mined lands, it has been used successfully to predict productivity on lands reclaimed from other types of disturbance.

Presently, 121 acres of the Buckskin site are, or have been in the past, used as cropland. Under the present plan, these would be reclaimed as rangeland. An evaluation will be required to determine whether this sort of conversion would be allowed as an approved postmining land use.

Backfilling and Grading—Thin Overburden (30 CFR 715.14(g))

In surface coal mining operations carried out continuously in the same limited pit area for more than 1 year where the volume of all available spoil and suitable waste materials is demonstrated to be insufficient to achieve approximate original contour, surface coal mining operations shall be conducted to meet, at a minimum, the following standards:

(1) Transport, backfill, and grade, using all available spoil and suitable waste materials from the entire mine area, to attain the lowest practicable stable grade, which may not exceed the angle of repose, and to provide adequate drainage and long-term stability of the regraded area.

(2) Eliminate highwalls by grading or backfilling to stable slopes not exceeding 50% or such lesser slopes as the regulatory authority may specify to reduce erosion, maintain the hydrologic balance, or allow the approved postmining land use.

(3) Transport, backfill, grade, and revegetate to achieve an ecologically sound land use compatible with the prevailing land use in unmined areas surrounding the permit area.

(4) Transport, backfill, and grade to ensure that the impoundments are constructed only where it has been demonstrated to the regulatory authority's satisfaction that all requirements of 30 CFR 715.17 have been met and that the impoundments have been approved by the regulatory authority as meeting the requirements of this part and all other applicable federal and state regulations.

On the Buckskin site, overall lowering of the mined area and differential settlement could cause shallow ponding, peripheral gullying, changed drainage patterns, and other attendant impacts.

The shallow ponding would result from a general lowering of the reclaimed surface toward the water table level. Shallow ponding would affect the surface hydrologic system, and thereby affect the postmining land use

TABLE BU4-1
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
AIR QUALITY					
Generation of fugitive dust emissions would cause an increase in total suspended particulates (TSP)	-	(A) paving of access road	-	will reduce 85% of dust on access road	fugitive dust emission from the entire project would be reduced by 14%-23%
Visibility would be reduced by increased TSP	-	(A) paving of access road	-	will reduce 85% of dust on access road	visibility impacts would be lessened by an unknown amount
Slight amounts of NO_2, SO_2, and HC would be generated by vehicles	-	-	-	-	impact unchanged
GEOLOGY					
Part of the geologic record would be lost	-	-	-	-	impact unchanged
Ground stability would be decreased	-	-	-	-	impact unchanged
Rock hunting would be increased	-	-	-	-	impact unchanged

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
PALEONTOLOGY					
Potential fossil bearing strata would be lost	-	-	-	-	impact unchanged
Unauthorized fossil collecting would increase	-	-	-	-	impact unchanged
TOPOGRAPHY					
Smooth depressions would result after mining	-	(B) placement of rock outcrops	-	outcrops will alleviate smoothness of terrain	depression would be smooth with some irregular outcrops
Landforms would be altered during mining	-	-	-	-	impact unchanged
Some railroad and road cuts may remain after mining	-	-	-	-	impact unchanged

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
SOILS					
Soil productivity would be reduced after reclamation	30 CFR 715.13 30 CFR 715.16	-	soils handling and postmining land use	soil productivity on this site can only be restored to 87% of original productivity	13% long term loss of soil productivity
Soil productivity would be lost for new urban areas	-	-	-	-	impact unchanged
Soil productivity would be lost while areas are being mined	-	-	-	-	impact unchanged
Topsoil would be lost to erosion	30 CFR 715.16 30 CFR 715.20	-	topsoil handling and revegetation	90-95% of topsoil can be retained on the site	5-10% loss of topsoil during mining
Topsoil could be contaminated by toxic materials	30 CFR 715.16	-	topsoil handling	operator shall redistribute topsoil to prevent excess contamination	some contamination could still occur

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
GROUNDWATER					
Water quality would be lowered in spoils after reclamation	30 CFR 715.17	-	overburden back-filling monitoring	SMCRA requires "minimization" of water quality reduction	water quality in the spoils would probably be reduced to some extent
Water levels would be lowered in adjacent aquifers during mining	30 CFR 715.17	-	water supply, water monitoring	the operator will be required to replace water supplies lost to neighboring water users	water levels would still drop, but users would not be adversely affected
Valley floors designated as alluvial could be disturbed	30 CFR 715.17	-	various portions of entire M&R plan	in alluvial valley floors, operator must identify and study "essential hydrological functions" and either conduct operations to preserve these functions, or avoid mining such valley floors	in alluvial valley floors, "essential hydrologic functions" would be preserved

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
Water levels would be nearer the surface in spoils	30 CFR 715.14 30 CFR 715.17	-	overburden back-filling and grading monitoring	operator must monitor and conduct operations to minimize disturbance of hydrologic balance	water levels could still be nearer the surface
Infiltration and recharge would be altered in the spoil after reclamation	30 CFR 715.17	-	reclamation portion of plan, monitoring	reclamation will be conducted to restore "approximate" premining recharge capacity	infiltration and recharge could still be somewhat altered, but adverse effects are minimized
Coal and overburden aquifers would be destroyed by mining	-	-	-	-	impact unchanged
Consumptive use of groundwater could affect other users	30 CFR 715.17	-	water supply and monitoring	the operator will be required to replace water supplies lost to neighboring water users	other users will not be adversely affected

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
Peripheral gullying could result after reclamation	30 CFR 715.13 30 CFR 715.14 30 CFR 715.17	-	overburden back-filling and grading, postmining land use	slopes are to be equal or less than pre-mining slopes, this would eliminate 95% of gullying	some gullying (5%) would occur on slopes
During flooding, sedimentation would increase due to high stream velocities	-	-	-	-	impact unchanged
Breaching of bypass channel and impound-ments would release low quality water downstream	30 CFR 715.17	(H) diversion channel design	diversion channels and impoundments	diversion channels and impoundment are to be built to pre-vent changes in water quality	maximum flooding could still result in some breaching
Leachate and surface runoff could enter to surface water system during mining	30 CFR 715.17	-	sedimentation control, water monitoring	best control technology will be applied to control pollu-tion from runoff waters	reduction in water quality could occur, but adverse effects would be minimized

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
SURFACE WATER					
Surface water system would be destroyed by mining, water will be diverted around the mine	30 CFR 715.17	-	diversion channel	temporary diversion channels will be built to prevent changes in water quality and quantity	during mining, original system would be lost, but surface waters would be diverted in a manner to retain quantity and quality
After reclamation, surface water system would be altered from existing characteristics	30 CFR 715.13 30 CFR 715.14 30 CFR 715.17	(C) restoration of reservoirs	various portions of reclamation plan	changes in water quality, quantity and location shall be minimized to support postmining land use	surface water system characteristics could still be altered from existing ones, but adverse affects would be minimized
Shallow ponding could result after reclamation	30 CFR 715.13 30 CFR 715.14 30 CFR 715.17	-	overburden backfilling and grading, postmining land use	operator will conduct operations to minimize disturbance of hydrologic balance	shallow ponding could result in the long term due to settling of overburden

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITITATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
New rail and road access could split pastures and interrupt agricultural operations	-	-	-	-	impact unchanged
Surface water system alteration would affect agricultural operations	30 CFR 715.13 30 CFR 715.17	(C) restoration of reservoirs	reclamation portion of plan	surface water system will be reclaimed to minimize impact on water quality, quantity, and location	adverse impacts on agricultural operations would be minimized
Increased sediment release during floods would affect productivities	-	(H) diversion channel design	-	-	only maximum flooding would cause sedimentation downstream
121 acres of cropland would be destroyed and not reestablished by reclamation	30 CFR 715.13	-	reclamation portion of plan	reclamation will restore lands to the uses they were capable of supporting prior to mining	unknown

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
Increased surface water use by new population	-	-	-	-	impact unchanged
Water quality could be lowered by sewage effluents	-	-	-	-	impact unchanged
VEGETATION					
Vegetative productivity would be reduced after reclamation	30 CFR 715.13 30 CFR 715.16 30 CFR 715.20	-	topsoil handling revegetation, postmining land use	productivity levels can be restored on this site to 87% of pre-mining levels on this site	13% long term loss of vegetative productivity
Vegetative productivity would be lost for new urban areas	-	-	-	-	impact unchanged
Vegetative productivity would be lost while areas are being mined	-	-	-	-	impact unchanged
Species variety would reduced	30 CFR 715.20	-	revegetation	operator must establish a vegetative cover of a seasonal variety native to the area	grasses would be more successful initially, resulting in lack of variety in the short term

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
Vegetative productivity could be reduced by increased dust during mining	-	(A) paving of access road	-	will reduce dust from access road by 85%	reduction in vegetative productivity would be mitigated by an unknown amount
Fire hazard would be increased during mining	-	(D) fire prevention and control training	-	unknown	would likely reduce hazard and loss from wildfire
Aquatic vegetation would be adversely affected	30 CFR 715.13 30 CFR 715.14 30 CFR 715.17	-	reclamation portion of plan	surface water system will be reclaimed to minimize impact on water quality, quantity and location	aquatic vegetation would be lost during mining, but reestablishment of surface water system may allow vegetation to reestablish itself
Vegetative productivity could be reduced by topsoil erosion	30 CFR 715.16 30 CFR 715.20	-	topsoil handling and revegetation	90-95% of soil can be retained on site	some reduction in vegetative productivity could result from loss of 5-10% of topsoil

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
WILDLIFE					
Wildlife habitat quality would be reduced after reclamation (affecting populations and carrying capacity)	30 CFR 715.13	(B) placement of rock outcrops (C) restoration of reservoirs	postmining land use	cover (rock outcrops) and watering will be somewhat restored, vegetative productivity can only be 87% restored on site	some habitat would be restored but 13% of vegetative productivity (carrying capacity) would be lost in the long term
Wildlife habitat would be lost during mining	-	-	-	-	impact unchanged
Carrying capacity would be lost during mining	-	-	-	-	impact unchanged
Wildlife populations would be lost	-	(E) use of BLM fence specifications	-	75% effective in reducing animal deaths along fences	wildlife populations would be lost by displacement during mining, with some re-population following mining, only 25% of game animal deaths on fences would occur

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
Visual quality in new urban areas would be reduced from Classes II, III, or IV to Class V	-	-	-	-	impact unchanged
RECREATION					
Use of recreation facilities would be intensified	-	-	-	-	impact unchanged
"Primitive" recreation quality would be reduced	-	-	-	-	impact unchanged
Conflicts between landowners and recreationists would increase	-	-	-	-	impact unchanged
Numbers of huntable wildlife would be reduced	-	-	-	-	impact unchanged
Mining and urban increase would reduce the land use base	-	-	-	-	impact unchanged

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
Sightseeing of natural landscapes would be reduced	-	-	-	-	impact unchanged
AGRICULTURE					
AUMs (carrying capacity) would be reduced after reclamation	30 CFR 715.13	-	revegetation, post-mining land use	vegetative productivity can only be 87% restored on this site	long term loss of 13% of carrying capacity
AUMs would be lost while areas are being mined	-	-	-	-	impact unchanged
AUMs would be lost for new urban areas	-	-	-	-	impact unchanged
Forage productivity could be reduced by dust fallout	-	(A) paving of access road	-	will reduce dust from access road by 85%	reduction of forage productivity would be lessened by an unknown amount
Animal harrasment and unintention openings of enclosures would increase	-	-	-	-	impact unchanged

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
MINERAL RESOURCES					
Coal would be converted to electrical energy	-	-	-	-	impact unchanged
Some coal would not be recovered by mining technology	-	-	-	-	impact unchanged
Sand, gravel, and scoria would be consumed in construction activities	-	-	-	-	impact unchanged
TRANSPORTATION					
Rail traffic would increase	-	-	-	-	impact unchanged
Street and highway traffic would increase	-	-	-	-	impact unchanged
Traffic and use of the Gillette airport would increase	-	-	-	-	impact unchanged

TABLE BU4-1
(cont'd)
EFFECTIVENESS OF MITIGATION AND RESIDUAL IMPACTS

Description of Impact of Proposed Action	SMCRA* Requirement (30 CFR 700)	Committed or Enforceable Mitigating Measure	Phase of Proposed Action Potentially Requiring Change or Addition (for SMCRA only)	Indication of Effectiveness & Feasibility	Residual** Impact
SOCIOECONOMICS					
City of Gillette would experience increased fiscal stress	-	-	-	-	impact unchanged
Housing requirements and needs would intensify	-	-	-	-	impact unchanged
Quality of life and character of Gillette and Campbell County would be changed	-	-	-	-	impact unchanged
Employment and wages would increase	-	-	-	-	impact unchanged

* Surface Mining Control and Reclamation Act of 1977.
** "impact unchanged" entries in this column indicate no change from the impacts due to the proposed action.

for agriculture and wildlife. These impacts would be minimized by reconstructing the natural slopes as closely as possible; replacing the original contour and configuration of the natural drainage pattern as closely as possible; and compacting the backfill of the replaced valley floor which carries the new main stream channel. Sufficient extra overburden should be placed on top of the lowest areas of replaced overburden so that the stabilized contours after settlement are near those shown on the postmining contour map.

Topsoil Handling (30 CFR 715.16)

To prevent topsoil from being contaminated by spoil or waste materials, the permittee shall remove the topsoil as a separate operation from areas to be disturbed. Topsoil shall be immediately redistributed on areas graded to the approved postmining configuration. The topsoil shall be segregated, stockpiled, and protected from wind and water erosion and from contaminants which lessen its capability to support vegetation if sufficient graded areas are not immediately available for its redistribution.

On the Buckskin site, a reduction in quality would occur in stockpiled topsoil due to unavoidable erosion and loss of native seeds, microorganisms, organic matter, nutrients, and vegetative propagules. Accidental spillage of oil, gas, or other toxic materials would contaminate soil and render it useless for reclamation.

As long as there is only 18 inches of "topsoil"material present on the site as indicated in Table BU3-6, any soil amendments such as fertilizer or organic matter can only result in a temporary increase in productivity. If a greater depth of "topsoil"material were replaced, such as 30 inches, along with the appropriate soil amendments, the long-term productivity of the site should equal or exceed the premining productivity.

If a major flood occurs, such as a 25-, 50-, or 100-year flood, when topsoil material is exposed, accelerated unquantifiable erosion would occur which would result in large amounts of soil loss. (See also Committed Measure (H) below.)

Realistically, soil protective measures are not likely to be more than 90-95% effective in protecting topsoil.

Protection of the Hydrological System (30 CFR 715.17)

The permittee shall plan and conduct coal mining and reclamation operations to minimize disturbance to the prevailing hydrologic balance in order to prevent long-term adverse changes in the hydrologic balance that could result from surface coal mining and reclamation operations, both on and offsite. Changes in water quality and quantity, in the depth to groundwater, and in the location of surface water drainage channels shall be minimized such that the postmining land use of the disturbed land is not adversely affected and applicable federal and state statutes and regulations are not violated. The permittee shall conduct operations so as to minimize water pollution and shall, where necessary, use treatment methods to control water pollution. The permittee shall emphasize surface coal mining and reclamation practices that will prevent or minimize water pollution and changes in flows in preference to the use of water treatment facilities. Practices to control and minimize pollution include, but are not limited to, stabilizing disturbed areas through grading, diverting runoff, achieving quick-growing stands of temporary vegetation, lining drainage channels with rock or vegetation, mulching, sealing acid-forming and toxic-forming materials, and selectively placing waste materials in backfill areas. If pollution can be controlled only by treatment, the permittee shall operate and maintain the necessary water-treatment facilities for as long as treatment is required.

Specifically, 30 CFR 715.17 provides for protection of the hydrologic system by establishing requirements for:

—water quality standards and effluent limitations,

—surface water monitoring,

—diversion and conveyance of overland flow away from disturbed areas,

—stream channel diversions,

—sediment control measures,

—discharge structures,

—handling of acid and toxic materials,

—minimizing and monitoring effects on ground water recharge, flow, and quality,

—replacement of water supplies affected by mining operations,

—preservation of essential hydrologic functions of alluvial valley floors throughout the mining and reclamation process,

—permanent impoundments, and

—hydrologic impacts of roads and other transport facilities.

For alluvial valley floors, such as that identified on the Buckskin Mine site, the regulations require that surface coal mining operations conducted in or adjacent to alluvial valley floors shall be planned and conducted so as to preserve the essential hydrologic functions of these alluvial valley floors throughout the mining and reclamation process. These functions shall be preserved by maintaining or reestablishing those hydrologic and biologic characteristics of the alluvial valley floor that are necessary to support the functions.

Also, surface coal mining operations located west of the 100th meridian west longitude shall not interrupt, discontinue, or preclude farming on alluvial valley floors and shall not materially damage the quantity or quality of surface or groundwater that supplies these valley floors unless the premining land use has been undeveloped rangeland which is not significant to farming on the alluvial valley floors or unless the area of affected alluvial valley floor is small and provides negligible support for the production from one or more farms.

Also, before surface mining and reclamation operations may be issued a new permit, the permittee shall submit, for regulatory authority approval, detailed surveys and baseline data from which the degree of material damage to the quantity and quality of surface and groundwater that supply the alluvial valley floors may be assessed.

The surveys and data shall include (a) a map, at a scale determined by the regulatory authority, showing the location and configuration of the alluvial valley floor; (b) baseline data covering a full water year; (c) plans showing how the operation will avoid, during mining and reclamation, interruption, discontinuance, or preclusion of farming on the alluvial valley floors and will not materially damage the quantity or quality of water in surface and groundwater systems that supply such valley floors; (d) historic land use data for the proposed permit area and for farms to be affected; and (e) such other data as the regulatory authority may require.

The regulations (30 CFR 715.17) on alluvial valley floors further provide that the holder of a federal coal lease located within or adjacent to an alluvial valley floor west of the 100th meridian west from which coal was not produced in commercial quantities between August 3, 1976, and August 3, 1977, and for which no specific permit by the regulatory authority to conduct surface coal mining operations in the alluvial valley floors has been obtained, may be entitled to an exchange of the federal coal lease for a lease of other federal coal deposits, or to the conveyance by the Secretary of fee title to other available federal coal deposits in exchange for the fee title to such deposits, if the Secretary determines that substantial financial and legal commitments were made by the operator prior to January 1, 1977, in connection with surface coal mining operations on such lands.

The Secretary may, if he determines that the person is qualified for an exchange of federal coal leases or a conveyance of other federal coal deposits, take appropriate steps to complete the exchange of lands. The Secretary may require the person to submit additional information and a formal application for exchange.

On the Buckskin site, degraded land use and water quality downstream from the mine site from erosion and leachate from removed overburden may be totally mitigated through planting vegetation on soil storage piles and use of temporary diversions to impoundments. Velocities in bypasses which would be higher than those normally traversing the area in the natural stream may be mitigated by vegetating and roughening the channel. (This, however, decreases the efficiency of the bypass and defeats its purpose of diverting flood flows around the mine in the most expeditious manner.) Any effect higher water velocities might have farther downstream would probably be dissipated in a short distance after reaching the natural channel. Degraded water and land use downstream due to slugs of contaminants and sediment flushed out as a result of breaching of bypasses and impoundments may be completely eliminated through adequate hydraulic design and retaining portions of the stream valley within its natural channel.

Less grazing use due to lost point-watering sources (if the postmining water table is lowered through elimination of the original groundwater system) would be completely mitigated through replacement of as much water surface as had previously been in existence. This might be accomplished through the construction of stock ponds and wells tapping water below the spoil.

Possible water contamination through increased water use and wastes could be completely mitigated through proper sewage treatment facilities.

Characteristics of groundwater recharge, flow, and quality would be minimally changed on the Buckskin site. However, it is still anticipated that recharge and flow may be altered to some degree, and that water quality would be decreased, although data are not available to measure the degree of change.

Revegetation (30 CFR 715.20)

The permittee shall establish on all land that has been disturbed, a diverse, effective, and permanent vegetative cover of species native to the area of disturbed land or species that will support the planned postmining uses of the land.

Revegetation shall be carried out in a manner that encourages a prompt regrowth of vegetative cover and recovery of productivity levels compatible with approved land uses. The vegetative cover shall be capable of stabilizing the soil surface with respect to erosion. All disturbed lands, except water areas and surface areas of roads that are approved as a part of the postmining land use, shall be seeded or planted to achieve a vegetative cover of the same seasonal variety native to the area of disturbed land. Vegetative cover will be considered of the same seasonal variety when it consists of a mixture of species of equal or superior utility for the intended land use when compared with the utility of naturally occurring vegetation during each season of the year.

Where hayland, pasture, or range is to be the postmining land use, the species of grasses, legumes, browse, trees, or forbs for seeding or planting and their pattern of distribution shall be selected by the permittee to provide a diverse, effective, and permanent vegetative cover with the seasonal variety, succession, distribution, and regenerative capabilities of species native to the area. Livestock grazing will not be allowed on reclaimed land until the seedlings are established and can sustain managed grazing.

Where wildlife habitat is to be included in the postmining land use, the permittee shall consult with appropriate state and federal wildlife and land management agencies and shall select those species that will fulfill the needs of wildlife, including food, water, cover, and space. Plant groupings and water resources shall be spaced and distributed to fulfill the requirements of wildlife.

The ground cover of living plants on the revegetated area shall be equal to the ground cover of living plants in an approved reference area for a minimum of two growing seasons. The ground cover shall not be considered equal if it is less than 90% of the ground cover of the reference area for any significant portion of the mined area.

Species diversity, distribution, seasonal variety, and vigor shall be evaluated on the basis of the results which

could reasonably be expected using methods of revegetation approved by the regulatory agency.

On the Buckskin site, analysis indicates that, over the long term, soil productivity would stabilize at 87% of premining levels, thereby reducing vegetative productivity proportionately.

COMMITTED MEASURES

(A) The daily use of the access road by Buckskin Mine employees would generate fugitive dust emissions along the length of the road outside of the mine property. In order to keep these emissions to a minimum the applicant has agreed to put a chip-and-seal surface on the access road. This would reduce the generation of fugitive dust from access road traffic by 85%. Thus, 0.77 pounds of dust per vehicle mile traveled would be expected, as opposed to 5.16 pounds per vehicle mile traveled if the access road were not chipped and sealed. Annual emissions from the access road would be reduced from 206 tons per year to 31 tons per year. Paving of the access road satisfies best management practice as required by the Environmental Protection Agency (EPA). EPA interprets best management practice as those procedures or techniques that can be reasonably (determined on a case-by-case economic basis) used to control fugitive dust.

(B) Piles of rocks and boulders placed on reclaimed areas will replace destroyed rock outcrops (microhabitats) which provide wildlife cover. These outcrops should be placed at a rate which will yield a level or density approximating premining occurrence.

Mining would eliminate rock outcrops and other types of cover which provide areas for concealment, dens, and/or nesting, and the reclaimed portion of the site would be lacking cover until shrub species are reestablished.

This measure would reestablish the microhabitats, and would also relieve some of the "smoothened"appearance of topography after reclamation. The feasibility of this measure is dependent upon the amount of rocks and boulders available in the overburden material.

(C) Small reservoirs or depressions will be established during the reclamation of Spring Draw and Rawhide Creek for the collection of water, which will add to the value of the land for postmining land use. The Wyoming Department of Environmental Quality (DEQ) requested this measure in a letter to the permittee dated October 26, 1977.

The destruction of pools of standing water in Rawhide Creek due to mining activities would eliminate resting and nesting areas for waterfowl and shore birds and some essential life-sustaining areas for amphibians and some reptiles. It would also eliminate a primary source of drinking water for livestock, birds, and wildlife in the area of the mine.

If the retention of an equivalent amount of surface water can be maintained by artificially constructed pools, then the impact described would be almost totally reduced, with the exception that until aquatic and riparian vegetation becomes naturally established around these pools, the pools would not be as attractive to wildlife as they are presently.

(D) The mine operator will institute fire prevention and fire-fighting training programs as a part of the safety program. These training programs would have an indeterminate effect on reducing fire hazards and environmental and economic losses due to wildfire.

(E) Bureau of Land Management (BLM) fencing specifications which will allow deer and antelope migration will be used for fencing the mine and railroad spur. Woven-wire fences will be acceptable only where the animals must be excluded from a portion of the mine for their safety. DEQ requested this measure in a letter to the permittee dated October 26, 1977.

Use of three-wire fence with a maximum height of 38 inches and a smooth, barbless wire 16 inches above the ground would alleviate about 75% of the antelope and deer loss from entanglement in fences, entrapment during winter storms, or prevention of movement to areas of available food and water. Such fencing would lose some of its mitigating effect during the winter if snow depth is above the bottom wire and animals are forced to jump fences.

(F) Two known archeological sites (48 CA 89 and 48 CA 130) are specifically protected by the Wyoming State Archeologist's archeological clearance stipulations developed in accordance with state and federal law.

Stipulations in the archeological clearance (on file at the BLM Casper District Office) state, "No terrain altering activities should take place outside the proposed railroad corridor near 48 CA 89. This includes vehicular travel. If it is necessary to deviate from the present corridor, then additional archeological studies will be needed" If construction or vehicular traffic outside the railroad right-of-way is necessary, the Wyoming State Archeologist will be notified to complete studies and/or salvage of the tipi ring site.

The stipulation also states, "No construction or vehicular traffic should be allowed within 25 yards of 48 CA 130. Since 48 CA 130 is highly visible, care should be taken to prevent curiosity seekers, collectors, and other potential looters from digging in the site. Care should also be taken to assure that construction design does not cause new erosion to the shallow cultural deposits. If the site cannot be protected adequately, then additional studies, possibly complete salvage, will be necessary" The Wyoming State Archeologist will be notified to complete his investigation of the bison kill site if it is deemed necessary either to disturb the site during railroad spur construction and/or if vandalism by construction workers is likely. The permittee has added a disclaimer to this stipulation (letter from Shell, dated 1/14/78) saying that the company cannot be responsible for actions of people other than Shell personnel, since the land is privately owned and beyond their control.

This measure will be enforced by the regulatory authority and should be totally effective in protecting the known sites.

(G) As yet unknown archeological sites will be generally protected by stipulations included in the Wyoming State Archeologist's archeological clearance. Stipulations

in the clearance state that a professional archeologist will observe and monitor topsoil removal on each side of Rawhide Creek, that the Wyoming State Archeologist will be notified of any cultural resources unearthed during mining or construction, and that such resources will be protected until investigations can be made by a qualified archeologist or historian.

This measure will be enforced by the regulatory authority. A qualified archeologist acceptable to the regulatory authority will be contracted by the permittee to be present during the initial surface disturbance of all of those areas of alluvial or wind-laid deposits identified in the inventory. Should a site or sites of National Register significance be encountered, appropriate mitigation will be conducted in consultation with the State Historic Preservation Office and Advisory Council. The archeologist will test and/or salvage sites uncovered pending his or her professional judgement of the quality of such sites. The permittee may opt to conduct trenching and/or bore test holes on identified sensitive areas prior to mining or surface disturbances using an archeologist and acceptable methodology. Upon finding any type of cultural site, the operator will contact the regulatory authority.

The effectiveness of this measure depends on the amount of destruction a site would sustain as it is uncovered, and the ability and willingness of workers to recognize and report subsurface sites.

(H) Based on discussions with the Wyoming State Engineer's Office (personal communication, Paul Thompson 1978), as a condition on the issuance of a water channel diversion permit, the diversions constructed at Buckskin would have to be designed to accommodate the runoff resulting from back-to-back (24-hour) 100-year storms.

This type of engineering design would alleviate much of the potential for breaching of the diversion channel when runoff reaches the flood stage. This measure would also minimize secondary impacts to soils, water quality, and downstream vegetation.

CHAPTER 5

UNAVOIDABLE ADVERSE IMPACTS OF THE PROPOSED ACTION

The following adverse impacts of the proposed action would remain after application of the mitigating measures discussed in Chapter 4. Whether certain impacts (such as those related to visual resources or socioeconomics) are adverse is a matter of personal preference. To the long-time resident who cherishes a traditional lifestyle, change probably would be adverse. To new residents, and those interested in economic and urban development, signs of growth would probably be welcome.

Impacts are listed in their general order of significance.

The population increase attributable to the Buckskin Mine would be 843 by 1990, of which about 87% would live in Gillette. One additional policeman and ten additional teachers would be needed to serve these people. The incremental effect of Buckskin-related population increases on other community services (e.g., water, fire protection, health) in Gillette would be insignificant compared to the effect of total regional development.

The population increase due to Buckskin would comprise 6% of the total increase expected in Gillette by 1990. There would be corresponding increased pressure on the housing market and transportation facilities.

The Buckskin project would increase regional earnings by $14.2 million by 1990 (2.4% of total increase in regional earnings expected by 1990), contributing to local inflationary pressures and reducing the buying power of people on fixed incomes.

Coal train traffic, producing noise and traffic congestion, would amount to 14 unit trains (both ways) per week from the Buckskin Mine by 1990, or 2.3% of regional coal traffic.

The projected increase in the number of registered vehicles in Campbell and Converse counties as a result of Buckskin is 770, or about 3.7% of the total predicted increase for those counties.

Lowering of water levels would occur in the overburden and coal in the vicinity of the Buckskin Mine until mining is completed. The bottom of the coal (bottom of the mine) would be the water discharge point. The cone of depression would extend 1,000 to 1,500 feet in the overburden and 3 miles in the coal. Groundwater levels would be lowered an unquantifiable amount in the vicinity of municipal wells to supply the Buckskin-related population.

Disruption of the shallow groundwater system would eliminate lush foliage along Rawhide Creek and Spring Draw, as well as some some point-watering sources both within the mined area and for a distance of probably no more than 3 miles beyond it. These effects may last only for the life of the mine, or, depending on the relation of the reclaimed surface to the water table in the mined area, be permanent. Loss of point-watering sources would discourage stock and wildlife grazing in the area.

Water in replaced spoils would be higher in total dissolved mineral levels (e.g., calcium, magnesium, and sulfate ions) than in the original aquifers. Such changes may render the water unsuitable for drinking or irrigation.

Gillette's water and sewage treatment needs would be substantial by 1990, but would not be significantly affected by the Buckskin-related population increase.

Erosion and consequently sedimentation within the mine area would be greatly increased. Water erosion of soil from disturbed areas would amount to 10 to 30 tons per acre per year, or an increase of 5 to 25 tons per acre per year over rates from undisturbed land. Leachate from spoil piles and replaced overburden would reduce surface water quality (see Table R4-5 in the Regional Environmental Statement). Only a small portion of these impacts would be felt beyond the mine areas, unless very heavy storms (e.g., 100-year floods) cause breaching of the catchments and settling ponds.

Ponding of surface and/or groundwater may occur after reclamation in depressions as the overburden settles. The water quality may be too poor for stock or wildlife, particularly if the depressions intercept groundwater as well as collecting surface runoff. If ponding occurs on the reclaimed area due to interception of groundwater by the lowered ground surface, then a lake could form, removing 40 to 240 acres (depending on the degree of settling) from vegetative or agricultural production. Terrestrial wildlife habitat would be exchanged for aquatic, although the water quality in the lake could be too poor to support animal life.

By the end of the mine life, temporary disturbance of soil, vegetation, and wildlife habitat would occur on a total of 1,071 acres, causing loss of soil and vegetative productivity an average of 10 years and loss of wildlife carrying capacity for more than 10 years. By the end of mine life, permanent disturbance would occur on 45 acres where new houses are constructed for the mine-related population. In comparison, total acreage disturbed temporarily and permanently in the region by 1990 would be 50,603 and 2,200 respectively.

Soil productivity on reclaimed areas would be an estimated 87% of present levels. This is because significant amounts (20% to 30%) of the soil material used in reclamation would be of poor quality, due to high salinity or alkalinity, acidic content, or high clay content. (No better soil material is available to replace the poor qual-

ity soil.) Such material would inhibit or prevent revegetation, thus increasing erosion rates. Also, a 20% to 40% reduction in quality would occur in stockpiled topsoil due to the loss of seeds, microorganisms, organic matter, nutrients, and roots.

Contamination by spillage of toxic materials, such as oil and gasoline, or wind and water erosion would cause the loss of 5% to 10% of available topsoil material. Wind erosion of soil from the Buckskin site would amount to 85 to 110 tons per year, an increase of 70 to 90 tons per year over rates from the undisturbed area. As mentioned before, water erosion of soil would amount to 10 to 30 tons per disturbed acre per year.

The return of agricultural land to production after reclamation depends on the success of revegetation efforts. Assuming that livestock range production can be restored by 87%, a permanent loss of 13% production capability (25 animal unit months (AUMs)) annually would occur over premining levels. An additional permanent impact would be the loss of 8 AUMs annually on the 45 acres where new houses are constructed. An estimated 320 AUMs would be lost annually on the mine site for the life of the mine, for a total loss of 6,400 AUMs.

Vegetation on the Buckskin site presently consists of 65% shrub types and 35% grass types. About 70 different species were identified during Shell Oil's plant survey in the summer of 1976. After reclamation, vegetation is expected to consist of no more than 25% trees and shrubs and 75% grasses, and diversity would be much less (about 15 species, at least until native species invade the reclaimed area—see Chapter 1 for proposed seeding mixture). Lack of vegetative diversity reduces stability of the vegetative community and the variety of wildlife it supports.

Due to the proposed action, 121 acres of cropland would be lost. After the 121 acres are reclaimed for grazing, there would be a gain of 19 AUMs annually.

The increased population due to Buckskin (815, or about 4% of total increases in Campbell and Converse counties by 1990) would cause a corresponding increase in dispersed recreation activities (leading to possible adverse impacts to ranching operations), in the use of recreation facilities, and in degree of loss of the "primitive"recreation experience.

The estimated numbers of wildlife lost by the end of mine life as a direct result of the proposed action are: 1,752 nongame birds, 228 doves, 8 raptors, 12 ducks, 4,253 nongame mammals, 6 cottontails, 17 antelope, 1 deer, and an unknown number of reptiles and amphibians. Total estimated losses are shown in Table BU3-13. Increased human population due to Buckskin would result in unquantifiable wildlife losses due to harrassment, poaching, road kills, and domestic pets.

The mine pit, stripped areas, machinery, buildings, and support structures (power lines, railroad spur, and access road) would be visual intrusions in the characteristic landscape until abandonment and revegetation is complete.

The proposed action would result in the unavoidable mining and consumption of 80 million tons of coal and an amount of sand, gravel, and scoria (clinker) estimated to be over 80,000 cubic yards. Four million additional tons of coal, which is mixed with overburden or partings, would be unrecoverable by present mining methods.

Two cultural resource sites would be destroyed by the proposed action, and some information may thereby be lost, even with salvage.

Two other sites in proximity to the mine site or railroad spur might be subject to damage.

The approximately 4% increase in population due to Buckskin would contribute correspondingly to unauthorized collection or vandalism of cultural and paleontological resources.

Natural topography would be altered by the mine pit and cuts and fills, and then reclaimed to unnaturally smooth contours. Replaced overburden would be unstable, tending to settle or shift over time. Even though general topography of the area can be restored, cliffs and abrupt breaks presently a part of the topographic scene, cannot be restored.

Predicted annual total suspended particulate (TSP) concentrations would not be expected to exceed 15 micrograms per cubic meter beyond 1.5 miles south or north of the mine boundary with even less impact east and west of the mine boundary. Violations of the Wyoming air quality standards would not be predicted. No measurable effect on visibility would be expected outside the proposed mine boundary.

Gaseous pollutants (nitrogen and sulfur oxides and hydrocarbons) from vehicle emissions at the mine would have only a minute effect and be restricted to the immediate area of the mine.

CHAPTER 6

RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

Approval of the Buckskin mining and reclamation plan would allow mining of 80 million tons of coal over a 20-year period to meet national energy demands. Although Buckskin would be a new mine, coal mining is not new to Campbell and Converse counties. There are already fifteen coal mines in the region either operating or pending final approval, and the Buckskin site is only 2 or 3 miles from the currently operating Rawhide Mine. The proposed Buckskin Mine site is presently used for livestock grazing, and it could be returned to that use after reclamation.

The coal removed from the Buckskin Mine by 1990 would amount to 42 million tons (2% of all coal mined in the region by 1990); it would be consumed in the production of electricity outside the region. About 4 million tons of coal would be lost at the Buckskin Mine by the end of mine life, because current mining technology does not permit its economic separation from overburden and partings.

The 1978 population of Campbell and Converse counties is estimated at 25,500. By 1990, population increases in these counties due to the Buckskin project would amount to 815, or 3.7% of total increases expected in these counties by 1990.

In the short term, the Buckskin Mine would contribute to increased local income and stimulate retail and wholesale trade. The loss of buying power of people on fixed income would be a long-term effect.

Permanent employment at the Buckskin Mine would reach 133 by 1990; this project alone probably would not create a labor shortage in other sectors of the economy, although it would contribute (3.4% by 1990) to the effect of total regional mine employment. In the long term, the regional labor force would grow to meet the demands of all employers, and increased employment would tend to hold the unemployment rate at its current low level.

In the short term, the population increase attributable to the Buckskin Mine would contribute to community problems; in Gillette, the Buckskin-related population increase by 1990 would amount to 6% of total community growth expected. Rising housing prices and crowded conditions, crowding of classrooms, increased pressures on health care and transportation facilities, and overtaxing of local services would occur. However, in the long term, housing stock would increase to meet demand; new facilities would be built and personnel to man them would be hired; the tax base would increase to pay for these needs.

Since the Buckskin Mine site could be reclaimed, mining would represent a short-term commitment of land use. Following reclamation, construction of buildings on the site might be restricted due to decreased ground stability. Land occupied by expanded urban areas (45 acres to serve Buckskin-related population increases) would be permanently committed.

Short-term disturbance of the soil resource would disrupt the productivity levels, destroy existing soil profiles, and increase soil erosion losses on 1,071 acres by the end of mine life. Soil productivity levels could be restored in the long term to an estimated 87% of premining levels.

Development of the Buckskin Mine would result in short-term losses of vegetation on 1,071 acres by the end of mine life. Reestablished vegetation could support livestock grazing within 10 years after reclamation begins, and in the long term, productivity would probably stabilize at 87% of premining levels.

The use of 45 acres for housing and support services for the Buckskin-related population increase would be a long-term commitment of the land. Productivity in relation to soils, vegetation, livestock grazing, and wildlife habitat would be lost, but productivity as measured in benefits to people would be enhanced.

A total of 1,071 acres of wildlife habitat would be lost for the short term at the mine site, resulting in the direct loss of an estimated 1,752 nongame birds, 228 doves, 8 raptors, 12 ducks, 4,253 nongame mammals, 6 cottontails, 17 antelope, 1 deer, and an unknown number of reptiles and amphibians. Once reclamation is completed, repopulation, at least by small mammals and birds, is expected to be rapid.

The loss of 320 animal unit months (AUMs) of grazing annually would be a short-term loss.

The 270 acre-feet per year of water used for the Buckskin Mine and its associated population increase would not be available for other uses, but would become available again when the mining project is completed.

Salvage of the two cultural resource sites within the area to be mined would be a long-term commitment.

CHAPTER 7

IRREVERSIBLE AND IRREVTIEVABLE COMMITMENTS OF RESOURCES CAUSED BY THE PROPOSED ACTION

Approximately 80 million tons of coal would be extracted and consumed as a result of approval of the proposed action. An additional 4 million tons would be left as unrecoverable by present mining methods.

The population and wage increases attributable to Buckskin would contribute to the change in life-style occurring in the region.

Loss of human life due to rail, highway, or mine accidents would be irreversible and irretrievable. The estimated potential fatality rate for coal strip-mining is 1 per 14.3 million tons of coal produced or 5 to 6 lives for the 80 million tons of coal produced.

Water consumed at the mine site or by the increased population (approximately 270 acre-feet annually) would be unavailable for other uses during the life of the mine.

Destruction of the physical structure of the premining aquifers would be irreversible. Water in aquifers which develop after reclamation would be of poorer quality than in the premining aquifers.

Some premining point-watering sources along Rawhide Creek and Spring Draw would be destroyed; the resulting loss in water source density and dispersion could cause a reduction in wildlife habitat and grazing range.

Existing soil associations on 1,071 acres would be destroyed. Soil loss to erosion or contamination by toxic materials would be irreversible.

Livestock forage amounting to 14 AUMs annually would be lost, because (a) soil and vegetative productivity on 45 acres would be irreversibly lost to new homes, (b) 13% of the land's premining productive capability would be lost on 1,071 reclaimed acres, but (c) 121 acres of cropland would be reclaimed for grazing.

If significant ponding of groundwater on the settled overburden occurs, there would be further irretrievable loss of soil and vegetative productivity and of wildlife habitat on 40 to 240 acres.

There would be an irretrievable loss of vegetative production, approximately 320 animal unit months (AUMs) annually, and total wildlife carrying capacity on 1,071 acres for the life of the mine.

Wildlife which presently occupies the mine site would be displaced and lost, as would subsequent generations of offspring (see Table BU3-13).

Forty-five acres of wildlife habitat would be permanently lost due to construction of new homes.

The aquatic habitat which presently exists on the mine site would not be replaced, but a different community would reestablish itself.

Houses, service facilities, utilities, and roads built on approximately 45 acres to accommodate the increased population would irreversibly commit visual resource Class II, III, and IV areas to Class V.

The land surface on the mine site, which includes cliffs, abrupt breaks, and rolling hills, could not be restored to its original conformation.

Cultural resources in areas of surface disturbance would be committed to either destruction or salvage; in either case, additional information would not be available to future researchers.

The removal by amateurs of collectible minerals, fossils, or cultural resources would be an irreversible loss.

CHAPTER 8

ALTERNATIVES TO THE PROPOSED ACTION

The U.S. Geological Survey has accepted the Buckskin mining and reclamation plan as adequate for environmental review and subsequent approval under the 30 CFR 211 regulations of May 1976. As discussed in earlier parts of this analysis, this plan may require revision to comply with the recently enacted Surface Mining and Control and Reclamation Act of 1977 (SMCRA).

In acting on this mining and reclamation plan, the Secretary of the Interior's action may be: approval as proposed, rejection on various environmental or other grounds, approval in part and rejection in part, or approval subject to such additional conditions, requirements, or modifications as he may impose under existing law and regulations. He may also defer decision pending submission of additional data, completion of required studies, or for other specific reasons.

Even after a mining and reclamation plan is approved, the regulations and lease terms require that all subsequently proposed departures and deviations therefrom be approved in advance by the Secretary. The regulations (30 CFR 211 and 700) also permit the Secretary to direct that changes be made in previously approved operations. For example, changes could be ordered to accommodate new, improved, or revised administration requirements, technologic improvements, environmental concerns or requirements, or revisions of prior evaluations thereof in the light of experience or previously unknown factors.

NO-ACTION ALTERNATIVE

"No action"on a mining proposal for the initial development of an existing federal lease would result in maintaining the status quo on the lease. Should no action be taken on the Buckskin mining and reclamation plan, the anticipated markets would have to locate another source to supply 80 million tons of low-sulfur coal. No action on the mining plan would cause the city of Gillette and surrounding towns to lose the increased income population, and services generated by the mining operation. The county, state, and federal governments would lose revenue generated by sales taxes, property taxes, and royalties.

If no action is taken on the mining plan, and if current land use of the area continues, most resources on the proposed Buckskin site would remain essentially unchanged. Some decrease in air quality could be anticipated due to urban expansion, increased traffic, and the development of other mines. Imperceptible alterations in soils and topography might occur by 1990 due to natural forces such as erosion. Increased hunting, rockhounding, and off-road vehicle use may occur on the site with or without landowner permission, due to the pressure of regional population increases.

No action on the mining plan would also cause: (1) retention of 84 million tons of low-sulfur coal for future use, (2) retention of 1,071 acres of surface and subsurface features on the site in essentially their present state, and (3) alleviation of some adverse socioeconomic impacts on the city of Gillette and nearby towns.

DEFER-ACTION ALTERNATIVE

For proper cause, the Secretary may defer final action on this proposed mining and reclamation plan. These causes could include, but are not limited to, the need and time required for:

1. Modification of the proposal to correct specific administrative or technological deficiencies. Such modifications may be necessary to bring this mining and reclamation plan into compliance with state and federal regulations engendered by the implementation of SMCRA.
2. Redesign to reduce or avoid specific environmental impact. Such design changes are identified later in this chapter under the alternative titled "Approval of the Mining and Reclamation Plan after Modification" Chapter 4 of this analysis also discusses design changes which may be required to reduce specific environmental impacts not addressed by SMCRA.
3. Acquisition of additional data to provide an improved basis for further technological or environmental evaluation of the proposal and/or alternatives. Additional data and evaluation may be required to demonstrate compliance with or meet requirements of SMCRA.

Data needs would probably occur in the area of hydrology, geology, mechanics and settling of fill materials, reclamation, and biological productivity.

The principal effects of deferring action on the proposal would be: (1) a short-term delay in development and supply of coal, (2) some reduction or avoidance of certain significant adverse impacts, or (3) a better data base and subsequent analysis of specific adverse impacts.

ALTERNATIVE TO PREVENT DEVELOPMENT ON THE LEASE

The Secretary may reject any individual proposed activity that does not meet the requirements of applicable

law and regulations under his authority, including the potential for environmental impact that could be reduced or avoided by adoption of a significantly different designed course of action by the operator. This may be accomplished by cancellation of the lease (if environmentally acceptable development is not possible), federal acquisition of the lease, or rejection of the mining and reclamation plan. Any of these would have the effect of precluding development, and the effects would be similar to those expected with the no-action alternative.

ALTERNATIVE TO RESTRICT DEVELOPMENT ON THE LEASE

This alternative could be applied to all or a portion of the lease, as appropriate. The federal coal lease conveys the right to develop, produce, and market the federal coal resource if all other terms and conditions are met by the lessee. Various measures that may tend to restrict development may be taken by the Secretary at any time in the interest of conservation of the resources or in the protection of various specific environmental values in accordance with existing law and regulations. Regulations promulgated to implement SMCRA may require restriction of development or operations on all or part of the Buckskin lease. At this time, however, the analysis has identified no specific portions of the lease where development should be restricted.

ALTERNATIVE TO CONDITION APPROVAL UPON DEMONSTRATION OF SUCCESSFUL RECLAMATION

The mining and reclamation plan would be conditionally approved for a period of 10 years during which time a specific testing and monitoring program for the purpose of measuring revegetation success would be implemented by the coal mining company. In this alternative a plan describing the testing and monitoring program would be prepared by the Shell Oil Company for approval by the regulatory authorities prior to its implementation.

If it cannot be demonstrated that revegetation can be successful commensurate with SMCRA at the conclusion of the 10-year program, the Department of the Interior will revoke its approval for mining.

Although current reclamation research indicates that successful reclamation can be achieved on semiarid mined lands, it is recognized that answers to reclamation problems are needed on a site-specific basis in order to ensure success.

This alternative, if implemented, would result in the gathering of data to show that lands proposed for mining are reclaimable within a reasonable period of time.

Shell Oil Company would be required, under the direction of state and federal reclamation regulatory agencies, to establish a suitable number of demonstration plots to provide evidence of revegetation success.

The demonstration plots would be established as soon as practicable following authorization to commence mining operations.

Impacts which would occur if revegetation could not be accomplished follow.

1. The mining company would be forced to shut down its operation.
2. A shut-down of the mine would cause economic loss to the mining company, loss of employment for most of the employees, and partial loss of investment in equipment and material needed to open and operate the mine for the 10-year period.
3. Areas disturbed during the 10-year period of mining would be unreclaimed or at best only partially reclaimed.
4. The consumer of coal from the mine would need to obtain coal from another source.

ALTERNATIVE TO APPROVE MINING AND RECLAMATION PLAN AFTER MODIFICATION

A number of the impacts identified and described in Chapter 5 of this analysis could be mitigated by the selective application of the following measures, which are beyond the committed mitigating measures discussed in Chapter 4.

Coal Transport by Conveyor Belt

It may be possible to reduce traffic along the haul roads by building a flexible conveyor system to transport coal from the point where the seam is being mined to the point where coal is crushed and loaded. The truck traffic required to haul the proposed 4 million tons of coal each year would contribute higher levels of fugitive dust than a conveyor belt. Fuel economy would likely be higher for a conveyor belt, than for truck haulage, and capital and operating costs may be lower. If a conveyor system is feasible, it may also be possible to use one to move overburden.

Fish and Wildlife Mitigation Alternatives

The recommendations which follow would reduce or eliminate the major impacts to existing fish and wildlife resources described in Chapter 3.

(1) All mining areas should be reclaimed to wildlife habitat as soon as feasible. Reclamation would be in conformance to the postmining land use established by the State of Wyoming (Department of Environmental Quality) and/or the Bureau of Land Management. Vegetative planting and reclamation should be accomplished in consultation with the Wyoming Game and Fish Department and the U.S. Fish and Wildlife Service. The goal of reclamation should be to achieve the highest possible wildlife carrying capacity at the earliest possible date, regard-

less of cost. All possible tools to achieve this goal should be implemented as needed.

(2) Approximately 1,500 acres of land lying in a suitable area where public domain (or private land under cooperative agreement) is available should be set aside and managed intensively for fish and wildlife resources. Selection of such an area should be accomplished in consultation with the Wyoming Game and Fish Department and the U.S. Fish and Wildlife Service. The area set aside should be managed to increase its wildlife carrying capacity by at least 50%. Management tools such as water development, fertilization, vegetative manipulation, spraying, transplanting, seeding, protection of wildlife cover, and management of livestock grazing to enhance wildlife habitat should be implemented as necessary. The habitat should be controlled by the surface-management agency and wildlife by the Wyoming Game and Fish Department.

(3) It should be provided that a mine permit will not be granted on land critical to the ecological requirements of the bald or golden eagle. A team of qualified biologists from the U.S. Fish and Wildlife Service,, the Wyoming Game and Fish Department, and the Bureau of Land Management will judge and recommend the areas to be excluded from mining. A mine permit could be granted if regulations are adopted to provide for buffer zones and alternate prey bases and nesting sites, and if that acreage critical to the eagle is not affected.

ALTERNATIVE TO ALLOW DEVELOPMENT OF SELECTED AREAS NOW UNDER LEASE

This alternative would permit only selective exploration and development of portions of the lease based on anticipated adverse environmental consequences. The decision-maker has the authority and responsibility to evaluate the coal resources and impacts of mining on the lease prior to acting on the proposal. Exploration and development could be allowed only on that portion of the lease where the fewest adverse environmental consequences would occur. Weighing the trade offs of mining or precluding mining on part of the tract is part of the evaluation and decision process. Adoption of this alternative would reduce adverse effects by reducing the area in which the impacting activities could take place. Various requirements of SMCRA may, prior to action on the mining and reclamation plan, indicate a scheme of development on selected areas of the lease.

Table BU8-1

TOTAL ANNUAL EMISSION FOR EACH STUDY YEAR WITH

CHEMICAL STABILIZATION OF HAUL ROADS

Study year	Expected emission reductions (tons per year)	Annual emissions Without alternative	(tons per year) With alternative
1980	172	587	415
1985	368	1000	632
1990	423	1100	677
1999	216	804	588

CHAPTER 9

CONSULTATION AND COORDINATION

See the Regional Environmental Statement (ES), Chapter 9, for a description of the consultation and coordination efforts involved in the preparation of the draft ES.

APPENDIX

SOILS

Arvada Soils

The Arvada series is a member of the fine, montmorillinitic, mesic family of Ustollic Natrargids. Typically, Arvada soils have thin platy A2 horizons, fine-textured B2t horizons having columnar to blocky structure, and moderate accumulations of calcium carbonate, calcium sulfate, and other salts.

Typifying Pedon. Arvada fine sandy loam-grassland. (Colors are for dry soil unless otherwise noted.)

A2 0-4"—Light gray (10YR 7/2) fine sandy loam, grayish brown (10YR 5/2) moist; moderate very thin platy structure that parts to moderate fine granules; soft; very friable; vesicular; noncalcareous; mildly alkaline (pH 7.8); abrupt smooth boundary; 0 to 6 inches thick.

B2t 4-14"—Brown (10YR 5/3) clay, dark brown (10YR 4/3) moist; moderate medium columnar structure that parts to moderate medium angular blocks; extremely hard, firm, very plastic; moderate continuous waxlike coatings on faces of peds and in root channels; strongly alkaline (pH 9.2); 20% exchangable sodium; clear smooth boundary; 8 to 14 inches thick.

B3casa 14-20"—Brown (10YR 5/3) heavy clay loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; extremely hard, firm, very plastic; weak visible accumulation of calcium carbonate and other salts as crystals, in concretions, and in thin seams and streaks; few thin glossy patches on faces of peds; some waxlike fillings in root channels; calcareous; very strongly alkaline (pH 9.0); 20% exchangeable sodium; gradual smooth boundary; 5 to 10 inches thick.

Ccasa 20-60"—Light yellowish brown (2.5Y 6/3) heavy clay loam, light olive brown (2.5Y 5/3) moist; massive; hard, friable; moderate accumulation of visible calcium carbonate and other soluble salts as crystals, in thin seams and streaks, and in concretions; strongly alkaline (pH 8.8); 20% exchangable sodium.

Type Location. Sheridan County, Wyoming; 650 feet south and 200 feet west of the NE corner of Section 29, T. 55 N., R. 87 W.

Range in Characteristics. Depth to calcareous material ranges from 0 to 12 inches, thickness of solum ranges from 15 to 30 inches. Average content of organic carbon in the upper 15 inches exceeds .6%. Thin A1 horizons occur in some pedons. Light-colored platy A2 horizons are generally present but are absent in some pedons. Content of coarse fragments is typically less than 5% and ranges from 0% to 15%. Mean annual soil temperature ranges from 47° to 58°F, and mean summer soil temperature ranges from 59° to 78°F. Length of time the soil temperature at 20 inches exceeds 41°F normally ranges from 230 to 305 days. Length of time (cumulative) the soil is moist in some part of the moisture control section while the soil temperature at 20 inches is above 41°F normally ranges from 56 days to 152 days, but in most years it should not be less than one-fourth or more than one-half of the time the soil is above 41°F. The A horizon has hue of 2.5Y to 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 through 4. It is typically clay but the percent of clay ranges from 35% to 60%, of silt from 10% to 50%, and of sand from 5% to 50%. It ranges from strongly alkaline to very strongly alkaline (pH 8.8 to 10.0) and has from 15% to 34% exchangeable sodium. Its cation exchange capacity ranges from 70 to 100 milliequivalents per 100 grams of clay. The C horizon has hue of 2.5Y to 10YR. It ranges from strongly alkaline to very strongly alkaline (pH 8.6 to 10.0) and contains 4% to 12% calcium carbonate equivalent. Exchangeable sodium typically ranges from 10% to 30% but generally decreases with depth.

Principal Associated Soils. These are the Absted, Renohill, and Ulm soils. Absted soils have less than 15% sodium in the upper part of the argillic horizon. Renohill and Ulm soils lack natric horizons.

Bankard Series

The Bankard series is a member of the sandy, mixed family of Ustic Torrifluvents. Typically, Bankard soils have calcareous, granular A horizons and strongly stratified but predominantly sandy, calcareous C horizons.

Typifying Pedon. Bankard loamy sand-grassland. (Colors are for dry soil unless otherwise noted.)

A1 0-5"—Light brownish gray (2.5Y 6/2) loamy fine sand, grayish brown (2.5Y 5/2) moist; weak fine granular structure; soft, very friable; calcareous; moderately alkaline (pH 8.0); clear smooth boundary; 4 to 8 inches thick.

C 5-60"—Light yellowish brown (2.5Y 6/3) fine sand stratified with thin lenses of sandy loam and loam, light olive brown (2.5Y 5/3) moist; the weighed average texture is loamy fine sand; single grained; soft, very friable; calcareous; moderately alkaline (pH 8.2).

Type Location. Morgan County, Colorado; 100 feet south and 210 feet east

Range in Characteristics. The soils are typically calcareous throughout but are noncalcareous in the upper few

inches in some pedons. Organic carbon in the A horizon ranges from .6% to 1.5%, but is typically less than 5%. Weak accumulations of secondary carbonate as soft concretions or seams are present in some pedons. Mean annual soil temperature ranges from 47° to 58°F, and mean summer soil temperature ranges from 60° to 78°F. The A horizon has hue of 2.5Y through 7.5YR, value of 5 or 6 dry, 3 through 5 moist, and chroma of 2 through 4. Typically the horizon has granular or crumb structure but is subangular blocky in some pedons. It is soft to slightly hard and is moderately alkaline. The C horizon has hue of 2.5Y through 7.5YR. It is moderately or strongly alkaline. Calcium carbonate equivalent ranges from less than 1% to 10% depending upon character of individual strata, but there is no distinct continuous horizon of calcium carbonate accumulation.

Competing Series and their Differentiae. These are the Ellicott and Dwyer series. Ellicott soils are noncalcareous and formed in alluvial sediments derived from arkose formations containing a high proportion of medium and coarse angular granite sand and fine and very fine angular granite gravel. Dwyer soils have uniform texture in which organic carbon decreases uniformly with depth.

Setting. These soils are on gently sloping to nearly level floodplains and low terraces. Slope gradients typically range from 0% to about 6%. The soils are formed in calcareous, highly stratified but predominantly coarse-textured recent alluvium derived from a variety of rocks. At the type location, the average annual temperature is 48°F, the average summer temperature is 70°F. Average annual precipitation is 14 inches with peak periods of precipitation in the spring and early summer months.

Principal Associated Soils. These are the Glenberg and Haverson soils. Glenberg soils have coarse-loamy control sections. Haverson soils have fine-loamy control sections.

Drainage and Permeability. Well to somewhat excessively drained; slow or very slow runoff; rapid or very rapid permeability.

Use and Vegetation. These soils are used chiefly as native pastureland, however, they are tilled in some localities. Native vegetation is scattered cottonwood, grass, and brush.

Distribution and Extent. The floodplains and low terraces of the major streams in Colorado, Wyoming, New Mexico, and parts of Montana, South Dakota, and Nebraska.

Series Established. Red Willow County, Nebraska, 1965.

Bowbac Series

Typifying Pedon. Bowbac sandy loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-4"—Grayish brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moist; moderate very fine and fine crumb structure; soft, very friable, slightly sticky, slightly plastic; many very fine and fine, common medium roots; mildly alkaline (pH 7.4); clear smooth boundary; 3 to 6 inches thick.

B21t 4-10"—Brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) moist; weak medium and fine prismatic that parts to moderate medium and fine subangular blocky structure; hard, friable, slightly sticky, slightly plastic; common very fine and fine, few medium roots; thin, nearly continuous, thick patchy glossy coatings on faces of peds; mildly alkaline (pH 7.5); clear smooth boundary; 0 to 6 inches thick.

B22t 10-16"—Brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) moist; strong medium and fine prismatic that parts to moderate medium subangular blocky structure; hard, firm, sticky, plastic; few very fine and fine roots; moderately thick continuous glossy coatings on vertical faces of peds and thin nearly continuous glossy coatings on horizontal faces of peds; mildly alkaline (pH 7.6); clear smooth boundary; 5 to 10 inches thick.

B3ca 16-22"—Light yellowish brown (10YR 6/4) sandy clay loam, brown (10YR 5/3) moist; weak medium and fine subangular blocky structure; slightly hard, very friable, slightly sticky; few thin patches of glossy coatings on faces of peds; calcareous; fine soft rounded masses of secondary calcium carbonate; moderately alkaline (pH 8.2); gradual wavy boundary; 4 to 8 inches thick.

C1 22-32"—Light yellowish brown (10YR 6/4) sandy loam, brown (10YR 5/3) moist; single grained; soft, very friable; calcareous; moderately alkaline (pH 8.2); gradual wavy boundary; 8 to 12 inches thick.

Cr 32-40"—Soft, partially weathered, calcareous sandstone.

Type Location. Converse County, Wyoming; SE¼, SW¼ of Section 8, T. 36 N., R. 72 W.

Range in Characteristics. Depth to paralithic contact is 20 to 40 inches; depth to calcareous material is 10 to 20 inches. The solum is 15 to 22 inches thick. Coarse fragments range from 0% to 15%. The A horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 or 3. It is neutral or mildly alkaline. The B2t horizon has hue of 2.5Y through 7.5YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 3 or 4. It averages between 18% and 35% clay and more than 35% fine sand or coarser. It is neutral or mildly alkaline. The C horizon has hue of 2.5Y or 10YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Olney soils. Olney soils lack bedrock above 40 inches.

Haverson Series

Typifying Pedon. Haverson sandy loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-6"—Grayish brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moderate fine crumb structure; soft, very friable, slightly sticky, slightly plastic; many very fine and fine roots; mildly alkaline (pH 7.6); abrupt smooth boundary; 3 to 6 inches thick.

C1 6-10"—Light brownish gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) moist; weak medium and fine subangular blocky structure; slightly hard, friable,

sticky, plastic; common fine and very fine roots; calcareous; moderately alkaline (pH 8.0); abrupt smooth boundary; 0 to 10 inches thick.

C2 10-60"—Grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) clay loam, and pale brown (10YR 6/3) sandy loam and sandy clay loam; massive; soft, very friable; few very fine and fine roots to 20 inches; common medium and fine pockets of organic stains throughout; calcareous; strongly alkaline (pH 8.5).

Type Location. Converse County, Wyoming; NW1/4NW1/4 of Section 31,T 40 N., R. 68 W.

Range in Characteristics. The soils are usually calcareous throughout but some pedons are leached a few inches. The control section is stratified with strata ranging in texture from sandy loam to clay loam. Weighed average clay ranges from 18% to 35%. It has more than 15% but less than 35% fine or coarser sand. Coarse fragments range from 0% to 15%. The A horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 3 through 5 moist, and chroma of 2 or 3. It is mildly or moderately alkaline. The C horizon has hue of 2.5Y through 7.5YR. Degree of stratification is variable. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Glenberg and Lohmiller soils. Glenberg soils have less than 18% clay in the control section. Lohmiller soils have more than 35% clay in the control section.

Olney Series

Typifying Pedon. Olney sandy loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-5"—Pale brown (10YR 6/3) sandy loam, brown (10YR 5/3) moist; moderate fine crumb structure; soft, very friable; common fine and very fine, few medium roots; neutral (pH 7.2); clear smooth boundary; 4 to 6 inches thick.

B1 5-10"—Pale brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) moist; weak medium prismatic that parts to moderate medium and fine subangular blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; common very fine and fine, few medium roots; thin patchy glossy coatings on vertical faces of peds; neutral (pH 7.2); clear smooth boundary; 3 to 6 inches thick.

B2t 10-24"—Light yellowish brown (10YR 6/4) sandy clay loam, brown (10YR 5/3) moist; moderate medium prismatic that parts to moderate medium and fine subangular blocky structure; hard, friable, sticky, plastic; few very fine and fine roots; thin nearly continuous glossy coatings; alkaline (pH 7.4); clear smooth boundary; 5 to 15 inches thick.

B3ca 24-30"—Light yellowish brown (10YR 6/4) sandy clay loam, brown (10YR 5/3) moist; weak medium and fine subangular blocky structure; few patchy glossy coatings on faces of peds; few soft rounded masses and seams of secondary calcium carbonate; moderately alkaline (pH 8.0); gradual wavy boundary.

Cca 30-60"—Very pale brown (10YR 7/4) sandy loam, light yellowish brown (10YR 6/4) moist; massive; slightly hard, very friable; moderately alkaline (pH 8.2).

Type Location. Converse County, Wyoming; SE1/4NW1/4 of Section 14, T. 36 N., R. 72 W.

Range in Characteristics. Depth to calcareous material ranges from 10 to 24 inches. Thickness of the solum ranges from 15 to 30 inches. Coarse fragments range from 0 to 15%. The A horizon has hue of 2.5Y or 10YR, value on 5 or 6 dry and 3 through 5 moist, and chroma of 2 or 3. It is neutral or mildly alkaline. The B2t horizon averages between 18% and 35% clay and more than 35% fine sand or coarser. It is neutral or mildly alkaline. The C horizon has hue of 2.5Y or 10YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Bowbac and Renohill soils. Bowbac soils have a paralithic contact at depths of 20 to 40 inches. Renohill soils have more than 35% clay in the B2t horizon.

Renohill Series

Typifying Pedon. Renohill clay loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-5"—Light brownish gray (10YR 6/2) clay loam, grayish brown (10YR 5/2) moist; moderate fine and very fine subangular blocky structure; slightly hard, friable, sticky, plastic; common very fine and fine, few medium roots; moderately alkaline (pH 7.6); clear smooth boundary 3 to 6 inches thick.

B2t 5-16"—Light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; weak coarse prismatic that parts to moderate coarse and medium angular blocky structure; hard, firm, sticky, plastic; few fine and very fine roots; moderately thick continuous glossy coatings on faces of peds; some pockets of olive brown (2.5Y 4/4) sandy material; mildly alkaline (pH 7.6); clear smooth boundary; 3 to 14 inches thick.

B3ca 16-25"—Light brownish gray (2.5Y 6/2) sandy clay loam, grayish brown (2.5Y 5/2) moist; weak medium and fine angular blocky structure; hard, friable, sticky, plastic; patches of thin glossy coatings on faces of peds; calcareous; few fine soft rounded masses of secondary calcium carbonate; mildly alkaline (pH 7.8); gradual smooth boundary.

Cr 25-30"—Calcareous sandy shale.

Type Location. Converse County, Wyoming; SW1/4NE1/4 of Section 14, T. 36 N., R. 73 W.

Range in Characteristics. Depth to calcareous material ranges from 6 to 20 inches. Thickness of the solum ranges from 15 to 30 inches. Depth to bedrock ranges from 20 to 40 inches. The A horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 or 3. It is neutral or mildly alkaline. The B2t horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 4 or 5 moist, and chroma of 2 through 5. It has 35% to 50% clay and more than 15% fine or coarser sand. It is neutral or mildly alkaline. The C horizon has hue of 2.5Y or 10YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Briggsdale, Cushman, Olney, Shingle, and Ulm soils. Briggsdale soils have more than 15% (absolute) clay increase in the argillic. Cushman and Olney soils have 18% to 35% clay in the argillic. Olney soils also have bedrock above 40 inches. Shingle soils lack argillic horizons and have bedrock above 20 inches. Ulm soils lack bedrock above 40 inches.

Samsil Series

The Samsil series is a clayey, montmorillonitic (calcareous), mesic, shallow Ustic Torriorthent. Typically, the Samsil soils have light brownish gray friable clay A horizons about 2 inches thick, light brownish gray friable clay AC horizons about 5 inches thick, and light brownish gray and light olive gray friable shaly C horizons underlain by light gray shale at a depth of about 17 inches.

Typifying Pedon. Samsil clay—on a convex, SSW facing slope of 15% under native grass. (Colors are for dry soil unless otherwise stated. When described, the soil was moist to 12 inches, dry from 12 to 21 inches, and moist below 21 inches.)

A1 0-2"—Light brownish gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) moist; moderate fine granular structure; slightly hard, friable, sticky, plastic; common roots; few very fine fragments of shale; slight effervescence; mildly alkaline; clear wavy boundary; 2 to 4 inches thick.

AC 2-7"—Light brownish gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) moist; weak medium subangular blocky structure parting to weak medium granular structure; hard, friable, sticky, plastic; common roots; common fine fragments of shale; slight effervescence; mildly alkaline; clear wavy boundary; 0 to 6 inches thick.

C1 7-11"—Light brownish gray (2.5Y 6/2) shaly clay, dark grayish brown (2.5Y 4/2) crushing to grayish brown (2.5Y 5/2) moist; massive; hard, friable, sticky, plastic; common roots; fine and medium fragments of shale make up about 30% by volume of mass; few fine faint stains of olive yellow (2.5Y 6/6); slight effervescence; mildly alkaline; gradual wavy boundary.

C2 11-17"—Light olive gray (5Y 6/2) shaly clay, olive gray (5Y 5/2) moist; massive; hard, friable, sticky, plastic; common roots; fine, medium, and coarse fragments of shale make up about 50% by volume of mass; common distinct stains of olive yellow (2.5Y 6/6) on faces of shale fragments; few fine and medium segregations of lime; slight effervescence; moderately alkaline; gradual wavy boundary. (Combined C1 and C2 horizons are 2 to 10 inches thick.)

C3 17-40"—Light gray (5Y 7/2) bedded shale; olive gray (5Y 5/2) moist; soft when moist but hard and brittle when dry; few roots; few iron and manganese stains in upper part.

Type Location. Pennington County, South Dakota; about 3 miles east of Wasta; 1,515 feet east and 1,120 feet south of the NW corner of Section 12, T. 1 N., R. 14 E.; 24 feet south of C & GS BM J381 (1962) on west side of Jensen Road.

Range in Characteristics. Depth to bedded shale ranges from 4 to 20 inches. Horizon above the shale ranges from loose to hard when dry, friable or firm when moist, and slightly sticky or sticky and plastic or slightly plastic when wet. These horizons contain free lime; effervescence ranges from slight to strong and from mildly alkaline through strongly alkaline. The C1 and C2 horizons and upper part of the C3 horizon commonly have segregations of lime, gypsum, and other salts. The horizons above the shale average between 45% and 65% clay. Colors throughout, including mottles and stains, are inherited from the shale. The A1 horizon has hue of 5Y, 2.5Y, or 10YR, value of 5 through 7 dry and 3 through 5 moist, and chroma of 2 through 4. It is clay or silty clay and commonly contains few or common fragments of shale ranging from 2 to 25 millimeters in diameter. It has fine or medium subangular blocky or fine or very fine granular structure. The upper $\frac{1}{4}$ to $\frac{1}{2}$ inches commonly is a fragile crust or mulch of very fine granules when dry. The AC and C horizons have hue of 5Y, 2.5Y, or 10YR, value of 5 through 7 dry and 3 through 5 moist, and chroma of 1 through 4. The C1 and C2 horizons contain from 5% to more than 50% fragments of shale that range from less than 2 to 35 millimeters in diameter. The C3 horizon or bedded shale has the same range in color as the overlying C horizons. It ranges from medium acid to moderately alkaline. The upper part or weathered zone is platy and contains free carbonates. The lower part separates to angular blocks and commonly lacks free carbonates except for segregations of lime as coatings or masses between fracture faces.

Competing Series and Their Differentiae. These are Chantier, Danko, Epsie, Lismas, and Midway soils in the family, and Conata, Grummit, Lisam, Louviers, Orella, Sansarc, and Yawdim soils. Chantier soils have B horizons. Lismas soils have harder consistence throughout. Midway soils contain less than 45% clay. Grummit soils are acid. Lisam and Yawdim soils are frigid. Louviers soils are nonacid. Orella soils are strongly or very strongly alkaline and contain from 8% to 30% exchangeable sodium. Sansarc soils are dry for a shorter period.

Setting. Samsil soils are on slope breaks of dissected shale plains. Surfaces mainly are convex, and slope gradients range from 2% to 45% or more. The soil formed in residuum weathered from shale. Mean annual temperature ranges from about 45 to 54°F; mean annual precipitation ranges from 12 to 17 inches, most of which falls in the spring and summer.

Principal Associated Soils. These are the Kyle, Pierre, and Swanboy soils, which are greater than 20 inches to shale. They are on the smoother parts of nearby landscapes.

Drainage and Permeability. Well-drained, somewhat excessively drained, and excessively drained. Surface runoff is slow on gently sloping areas and very rapid on steep areas. Permeability is slow.

Use and Vegetation. Rangeland. Native vegetation is little bluestem, needle-and-thread, sideoats grama, blue grama, green needlegrass, sedges, and forbs.

Distribution and Extent. Southwestern South Dakota and parts of Nebraska, Wyoming, and Colorado. The soil is extensive.

Series Established. Stanley County, South Dakota, 1967.

Remarks. Samsil soils were classified as Lithosols in the modified 1938 yearbook classification system.

Shingle Series

Typifying Pedon. Shingle sandy clay loam—rangeland. (Colors are for dry soil unless otherwise noted.)

A1 0-4"—Pale brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) moist; weak medium and fine crumb structure; soft, very friable, slightly sticky, slightly plastic; common medium fine roots; moderately alkaline (pH 7.9); clear smooth boundary; 3 to 6 inches thick.

C1 4-19"—Pale brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slightly plastic; few fine roots; 15% fine shale and sandstone fragments easily crushed; calcareous; moderately alkaline (pH 7.9); clear smooth boundary; 6 to 15 inches thick.

Type Location. Converse County, Wyoming; NW¼ of Section 15, T. 40 N., R. 70 W.

Range in Characteristics. Depth to soft bedrock is 10 to 20 inches. Depth to calcareous materials is 0 to 10 inches. The control section averages between 18% and 35% clay and has more than 15% but less than 35% fine or coarser sand. It has 0 to 15% fine shale or sandstone fragments. The A horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry and 3 through 6 moist, and chroma of 1 through 4. It is mildly through strongly alkaline. The C horizon has hue of 5Y through 7.5YR. It is moderately or strongly alkaline.

Principal Associated Soils. These are the Renohill, Samsil, and Tassel soils. Renohill soils have an argillic horizon. Samsil soils have more than 35% clay in the control section. Tassel soils have less than 18% clay in the control section.

Rough Broken Land/Rock Outcrop

The rock outcrop consists of multicolored, calcareous to noncalcareous, coarse to fine-textured, soft to hard sandstone, shales, and siltstone.

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